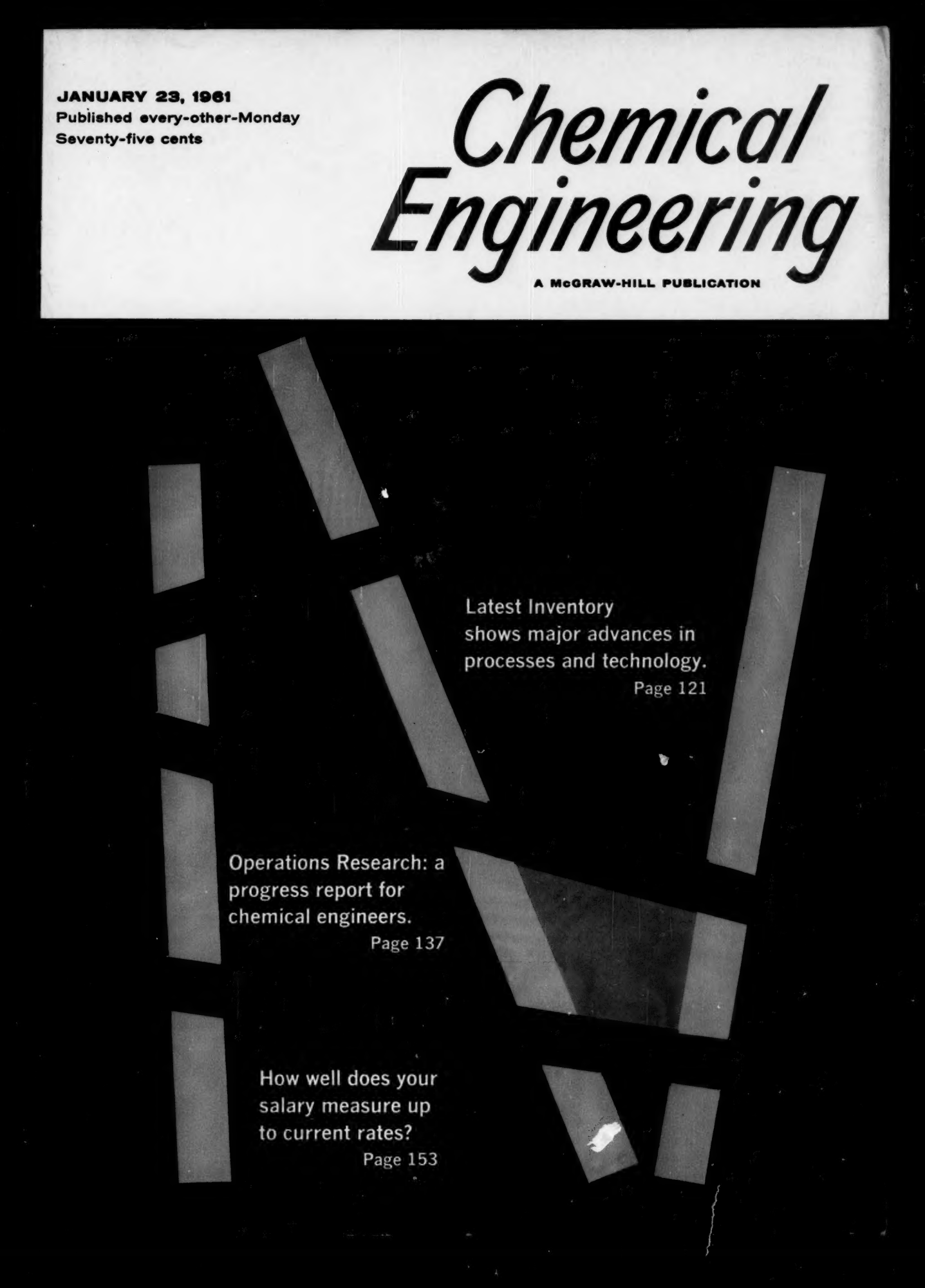
**JANUARY 23, 1961**
**Published every-other-Monday**
**Seventy-five cents**

# Chemical Engineering

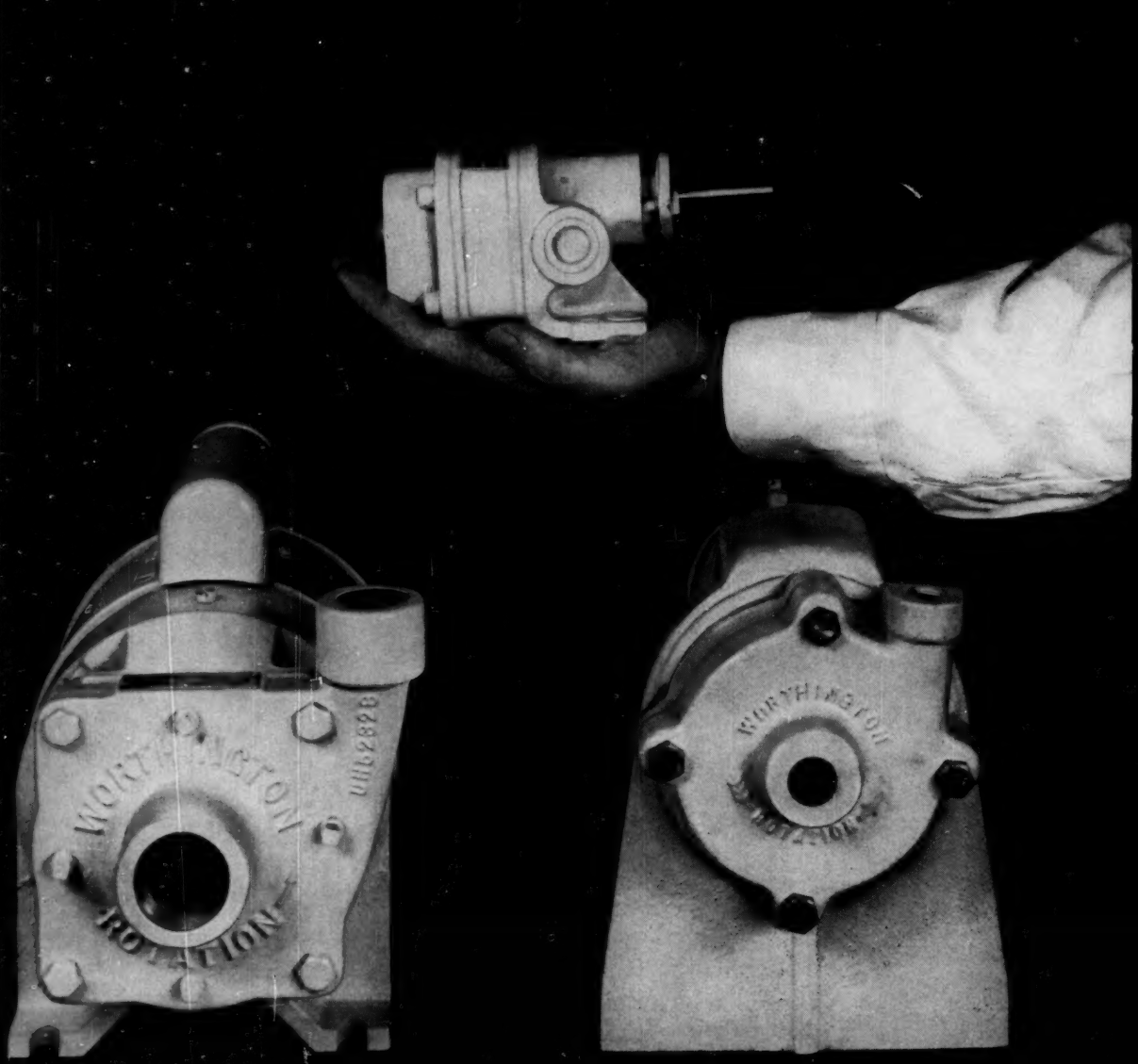
**A McGRAW-HILL PUBLICATION**



Latest Inventory shows major advances in processes and technology.
Page 121

Operations Research: a progress report for chemical engineers.
Page 137

How well does your salary measure up to current rates?
Page 153




# WE'RE BIG IN SMALL PUMPS, TOO

Yes, we're big in small pumps, too . . . so big that we have a complete, separate plant* for their production. But the real proof of how we can meet your small pump needs lies in the extent of our small pump lines. Look how these three new models stretch down to cover many more "small pump" applications.

Look at the new 1" Centrifugal which efficiently handles small flows from 2 to 80 gpm at heads to 110 feet. It's competitively priced, compact and trouble-free with smoother waterways and higher efficiencies.

Or look at the rotary which performs down to 4 gpm (150 psi) at 1750 rpm. It has one stuffing box to minimize leakage, few moving parts to cut maintenance, excellent suction lift, four-bearing construction, and the herringbone gears that are quieter and more efficient than spur gears.

For chemical and related industries, there is the new ⅜" Worthite pump with capacities to 18 gpm and heads to 55 feet. It has all the corrosion-resistant advantages of larger Worthite standard centrifugal pumps.

There are, of course, special advantages in buying small pumps from Worthington. One is that you're getting Worthington "big pump" quality. Another is that the small Worthington pumps are stocked and serviced coast-to-coast. Thus you can standardize in many locations and still get quick pump service anywhere. (Original equipment manufacturers, take note!)

For more information write Worthington Corporation, Section 20-25, Harrison, New Jersey.

*Located in East Orange, N. J. Our main large-pump plant is in Harrison, N. J.

WORTHINGTON

# APPLETON V-51 SERIES CONVERTIBLE VAPORTIGHT FIXTURES

*Require only seconds*

## to relamp or convert!

One trip up the ladder, a few quick twists of the wrist, and relamping or wattage conversion is done! V-51 reflectors with integral neoprene ring adapt perfectly to the grooved unilet... permit instantaneous substitution of reflectors.


U. S. Pat. 2,749,433
2,749,435 2,715,214
Canada Pat. 531,655
511,696

Maintenance man takes spare assembly to lamp requiring replacement or wattage change... removes lamp assembly ...screws fresh unit in place and the job is done! Higher wattages of 150/200 are interchangeable with 100 watt unit and can be used in same unilet body. (Die-cast aluminum guard turns counter clockwise to act as a tool for easy removal in relamping).

An upward thrust and slight quarter twist engages neoprene ring with the groove in the unilet and snaps the reflector in position. Entire operation of removing lamp, inserting new unilet, and positioning of reflector requires no special tools... no set screws... no small parts to juggle. Absolute simplicity!

For economical service and maintenance, it's hard to find anything more practical than Appleton's V-51 Series exclusive unit assembly (adapter, receptacle, globe, and guard). Shock absorbing socket cuts lamp replacement costs. Try the Appleton V-51 Series standard or shallow dome, deep bowl, or angle type reflectors and 100 W and 150/200 W vaportight unit assemblies in your plant today. Available in a variety of hub sizes in pendent, ceiling, or bracket type fixtures for every kind of installation.

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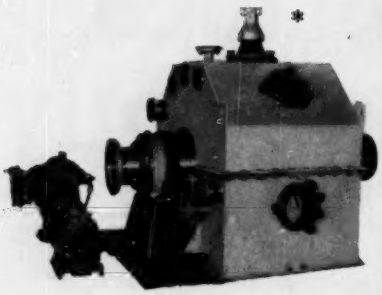

# LOOK HOW MUCH YOU CAN PUT THROUGH THIS SMALL SIZED BIRD-YOUNG VACUUM FILTER

| | |
|---|---|
| **Carboxy Methyl Cellulose** | **410** lbs./sq. ft./hr. |
| **Polyvinyl Acetate** | **2940** lbs./sq. ft./hr. |
| **Copolymer** | **1450** lbs./sq. ft./hr. |
| **Dimethyl Terephthalate** | **960** lbs./sq. ft./hr. |
| **Potato Starch** | **850** lbs./sq. ft./hr. |

Maybe *"your product is different"* — but if you're employing vacuum filtration, think how much you might save with through-puts like these. They're made possible by the Bird-Young Filter's unique design. High *washing efficiency* is another plus factor — multi-stage, counter current wash with sharp separation of filtrate and of wash liquors.

Before you invest in vacuum filtration of any kind, find out what the Bird-Young Filter can do. The Bird Research and Development Center offers complete test facilities.

*The Bird-Young Filter is equipped for totally enclosed, tightly sealed operation whenever required.

**BIRD MACHINE COMPANY**
SOUTH WALPOLE, MASSACHUSETTS

BUILDERS OF THE COMPLETE LINE OF SOLID-LIQUID SEPARATING EQUIPMENT
Operators of the Bird Research and Development Center for pilot-scale testing to determine the correct equipment for the job. Yours to use.
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# Chemical Engineering

PRINT ORDER FOR THIS ISSUE 53,074

January 23, 1961

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS


## WHAT'S HAPPENING



## OTHER REGULAR FEATURES



## ENGINEERING PRACTICE




VOLUME 68, NUMBER 2

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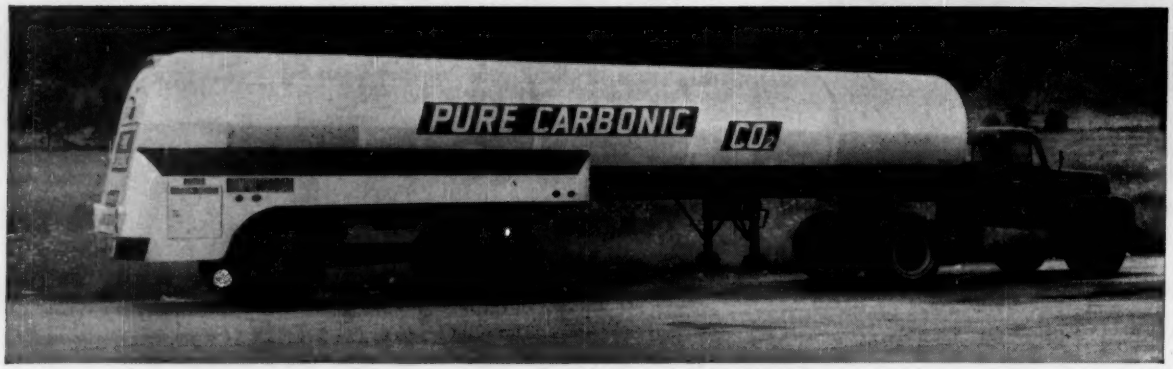


Hackney insulated transports for controlled or constant temperature applications. Engineered to deliver more miles of service per dollar invested. Built to your specifications, of T-1 steel, or various other steels, alloys, or stainless steels.

# Highway, in-plant or high seas

**For profitable hauling, Hackney transportation equipment pays off**

Wherever a compressed or liquefied gas requires a pressurized transportation vessel, you will find Hackney equipment doing the job—on the highways, within plants or on the high seas. And doing it at a profit to the user!

Every Hackney unit is engineered to meet service requirements, including complete piping, metering and transfer equipment...and temperature controls such as jackets, insulation, heating and refrigeration systems. Compliance with all regulations and highway laws is assured. Our facilities provide the latest equipment and engineering know-how for working all types of ferrous and nonferrous metals, as well as installing insulation, including popular "foamed-in-place" urethane.

Choose from our line of standard equipment or have our engineers design custom units for your special and unique applications. In either case, the Hackney trade-mark on your units is your assurance of complete attention to detail and consistent top quality. Call our representative today or write us direct for details.

Wagons for in-plant movements can be designed for any specific service.

Hackney single-barrel trucks are designed to speed loading and unloading of liquefied compressed gases. Built with all latest safety features and to comply with ICC specifications.

Tank units for land-sea shipment are interchangeable with dry freight containers.


Hackney single- or multi-compartment, noninsulated transports handle liquefied compressed gases such as refrigerants, LP-gas, ammonia, etc.

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*Manufacturer of Hackney Products*

**1447 South 66th Street, Milwaukee 14, Wisconsin**

**Branch offices in principal cities**

**COMPRESSED GAS CONTAINERS FROM 1 TO 30,000 GALLONS**

**Chemical Engineering**
JANUARY 23, 1961



# *highlights of this issue*

### ACTIVATED-SLUDGE PROCESS SOLVES WASTE PROBLEM

Three years ago this month Editor Cecil Chilton visited Monsanto's plant at Anniston, Ala., and came back with a story on parathion manufacture. During this visit he learned something about solving the problems involved in disposal of liquid wastes from this process. Persistent follow-up paid off when Monsanto recently invited *CE* back to the plant for an exclusive story on its newly installed waste-treatment facilities. This time Billy Barnes, our man in Atlanta, did the reporting job (p. 79).

### STEADIER COURSE FOR NAPHTHALENE

The U.S. as a net exporter of naphthalene? That's the prediction of UOP's G. E. Nicklaus (p. 84), who looks for petrochemical naphthalene to fill the growing demands of the U.S. economy and still have some left over to sell abroad. This would be a complete reversal from today's situation, in which inadequate coal-based supplies of naphthalene must be supplemented by imports.

### HOW TO MAKE POLYCHLOROMETHYL OXETANE

Hercules Powder's new thermoplastic, Penton, is already familiar to many chemical engineers as a material of construction with outstanding properties. Successful market development has recently boosted Penton into commercial-scale production at Parlin, N. J. Here's an exclusive story (p. 112) on how this plant synthesizes bis chloromethyl oxetane monomer from pentaerythritol and polymerizes it to produce Penton.

### THE NEW CHEMICAL ENGINEERING: FINALE

In this issue (p. 137 ff.) we publish the last three papers from our Conference on the New Chemical Engineering, held in Kansas City in November under joint sponsorship of Midwest Research Institute and *Chemical Engineering*. Reprints containing all ten conference papers will soon be available (see p. 152).

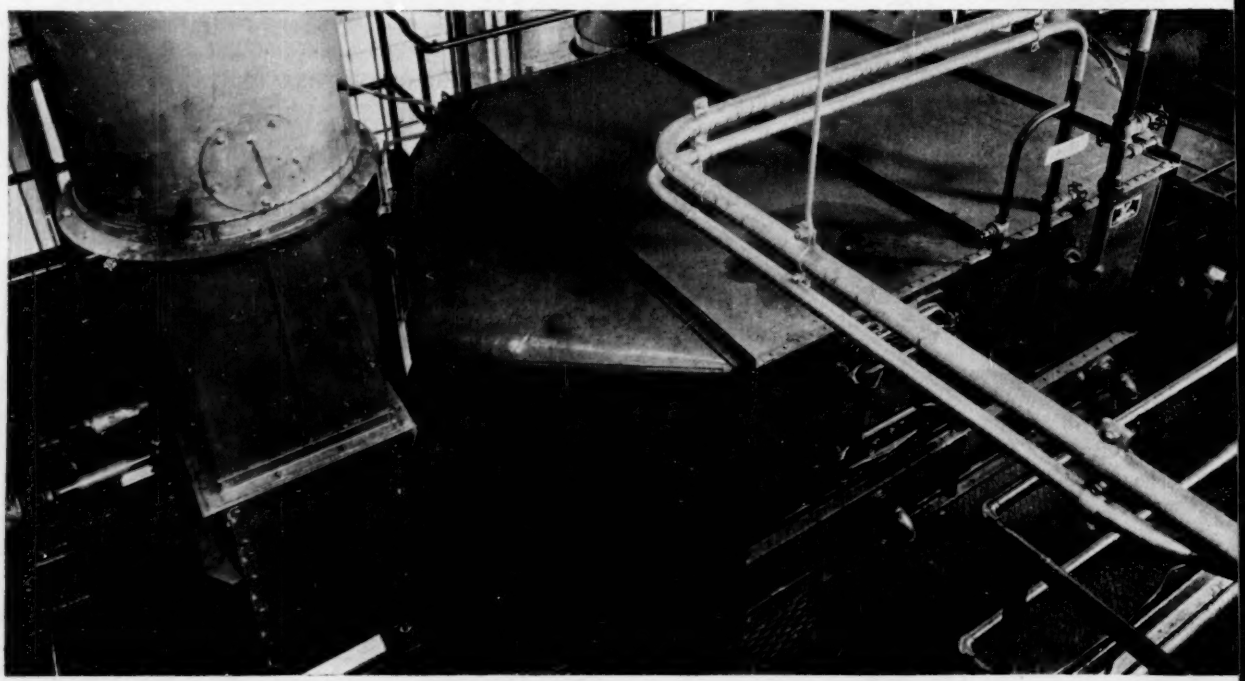
In many chemical process plants the very best air and liquid handling equipment is necessary for safe, reliable operation. It is here that you will most likely find 'Buffalo' equipment. Here are four units especially popular for these extra critical jobs.

# *Vital Air and Liquid Handling Jobs in CPI Performed by 'Buffalo' Equipment*

## EFFECTIVE CONTROL OF AIR POLLUTION

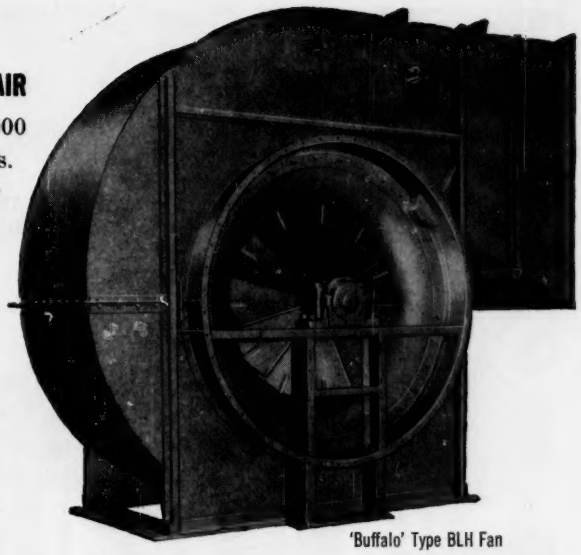
'Buffalo' Gas Absorbers have been designed to render many nuisance or destructive effluents harmless at a minimum operating cost. For example, they are removing entrained particulate matter from dryer vents — eliminating noxious gases from purge streams — scrubbing and absorbing corrosive acid mists and fumes from vent systems and many other applications. Available in carbon steel, rubber-lined steel, stainless or lightweight reinforced resin-bonded fiberglass to match the conditions of corrosion. Write for Bulletin AP-225. 'Buffalo' designs and builds a broad line of specialized Air Cleaning Equipment to handle a wide variety of problem effluents. Contact your resident 'Buffalo' Engineering Representative.

'Buffalo' Gas Absorber



## SUPPLYING VENTILATION AND PROCESS AIR

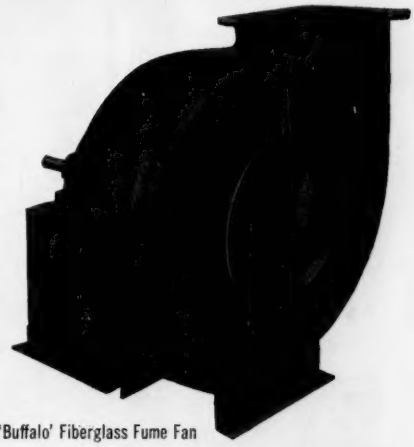
Where large volumes of air are needed (up to 500,000 cfm) you often find 'Buffalo' BLH Centrifugal Fans. For ventilation, air cleaning systems and process air in the CPI, these fans have earned a reputation for reliability, maintenance-free operation and rated performance. Complete inlet-to-outlet streamlining plus factory balanced rotor insures quiet, efficient performance on any class III or IV installation. For full details, request Bulletin 201.



'Buffalo' Type BLH Fan

## REDUCING THE COST OF HANDLING CORROSIVE FUMES

On many installations where corrosive acid mists and fumes would quickly destroy metal fans or lined fans, you find 'Buffalo' resin-bonded fiberglass fans ! Housings are impact and corrosion-resistant. Their smooth surfaces are resistant to pitting and buildup of materials. There are no metal parts exposed to attack. Suitable for temperatures up to 250°F. 12 sizes, 6" to 32" inlets, with capacities up to 34,000 cfm at pressures to 10" static. Send for Bulletin FI-511 with Chemical Resistance Table, physical properties and other details.



'Buffalo' Fiberglass Fume Fan

## PUMPING CHEMICAL LIQUIDS

Husky, single suction pumps available in cast iron or practically every alloy are handling a wide variety of chemical liquids. Models for corrosive, abrasive and high-consistency liquids. Full ball bearing construction permits high speed operation for high capacity with a minimum size pump. Interchangeable parts mean rapid, economical maintenance. Write us or tell your local 'Buffalo' Pumps Engineering Representative the characteristics of your chemical liquid to be pumped, the desired volume and head, temperature and suction lift — we'll match the right pump to the conditions, for the utmost in economical performance on the job.

'Buffalo' Single Suction Pump

**BUFFALO FORGE COMPANY**

Air Handling Division—Buffalo Pumps Division

Buffalo, New York

Canadian Blower & Forge Co., Ltd. • Canada Pumps, Ltd.
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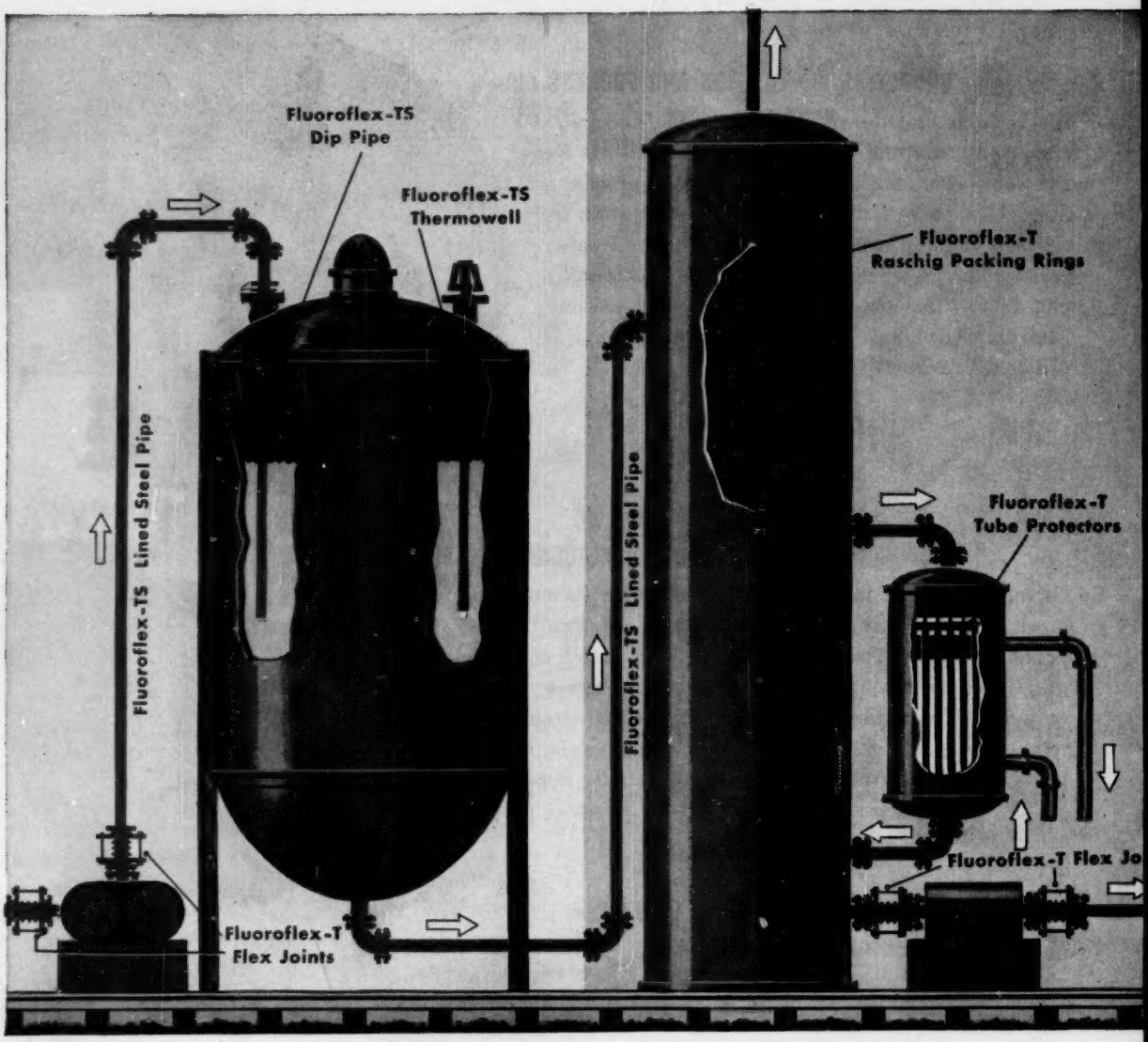
*'Buffalo' Air Handling Equipment to move, heat, cool, dehumidify and clean air and other gases.*

*'Buffalo' Machine Tools to drill, punch, shear, bend, slit, notch and cope for production or plant maintenance.*

*'Buffalo' Centrifugal Pumps to handle most liquids and slurries under a variety of conditions.*

*Squier Machinery to process sugar cane, coffee and rice. Special processing machinery for chemicals.*




# HERE'S WHY corrosion-proof fluid-handling production savings,

**Check these Fluoroflex-T piping components for economy, installation ease, long life!**

**FLUOROFLEX-TS—Lined Steel Pipe.** Prefabricated to length with flanges—ready to assemble. Minimizes assembly time, shortens checkout time.

**FLUOROFLEX-T—Bellows-Flex Joints.** Molded rather than machined, for unparalleled flex life. Damp out equipment vibration, adjust to longitudinal and temperature movements, add years to life of equipment and piping.

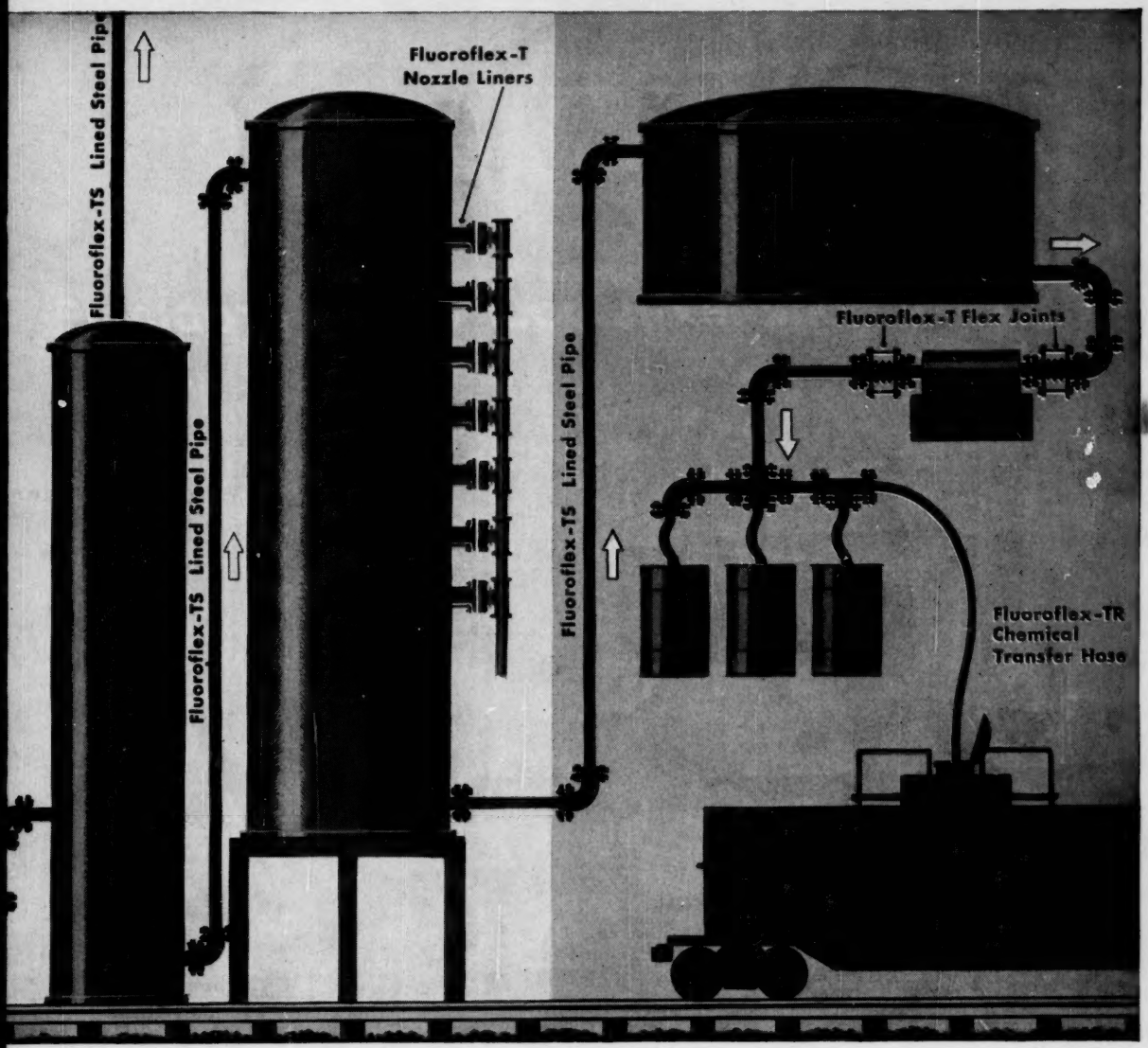
**FLUOROFLEX-T—Transfer Hose.** Completely corrosion-resistant, long flex life. Cover of rubber or stainless steel braid.

**FLUOROFLEX-T—Condenser Tube Protectors.** Eliminate erosion and corrosion by high-velocity acid on entry side of condenser tubes.

**Also: Raschig Packing Rings • Dip Pipes • Spargers • Thermowells.**

**Fluoroflex®-T Piping Products** as shown above can be used with complete and proven assurance that they will not corrode or build up solids which can contaminate sensitive products. Specially processed of Teflon® resins by patented Resistoflex methods, they can handle the most difficult materials up to 500°F. They are completely resistant to any chemical except high-temperature fluorine and the molten alkali metals.

**Fluoroflex-T Piping costs no more on an installed-cost basis** than other corrosion-proof systems in common use today. Initial material costs have been




## components of FLUOROFLEX-T (TEFLON) assure non-contamination:

lowered by recent price reductions made possible by advanced technology and increasing volume. Installation costs are inherently low as a result of skillful design which features easily-bolted-together units with prefabricated, flanged sections.

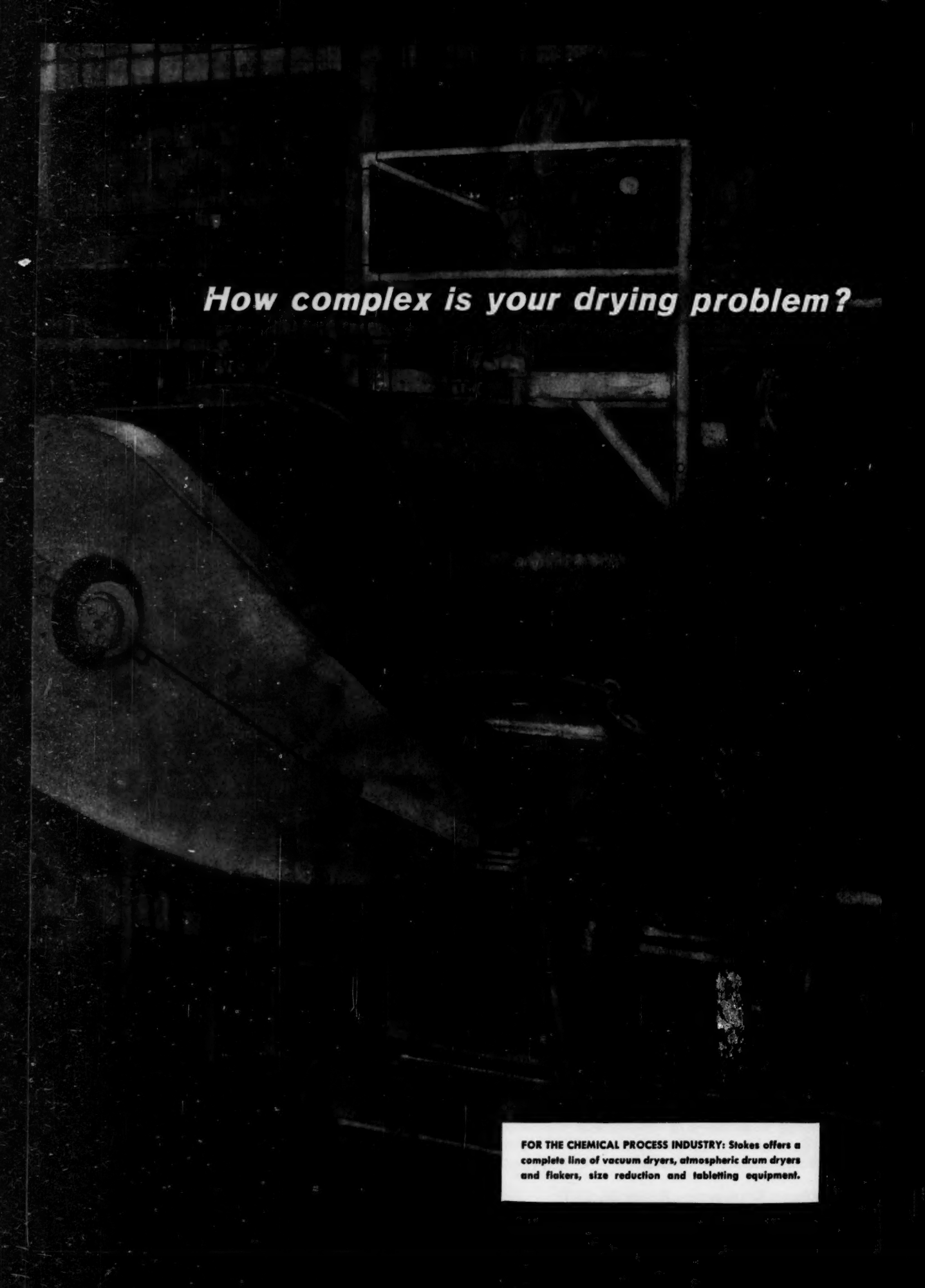
**Fluoroflex-T Piping costs LESS on a performance basis.** Savings in operation are assured—with decreased maintenance, long service life, and the elimination of process headaches and downtime.

So, if *you* have problems of corrosion—want to reduce maintenance or replacement costs and eliminate process downtime or product loss—consult Resistoflex. Write for more information today.

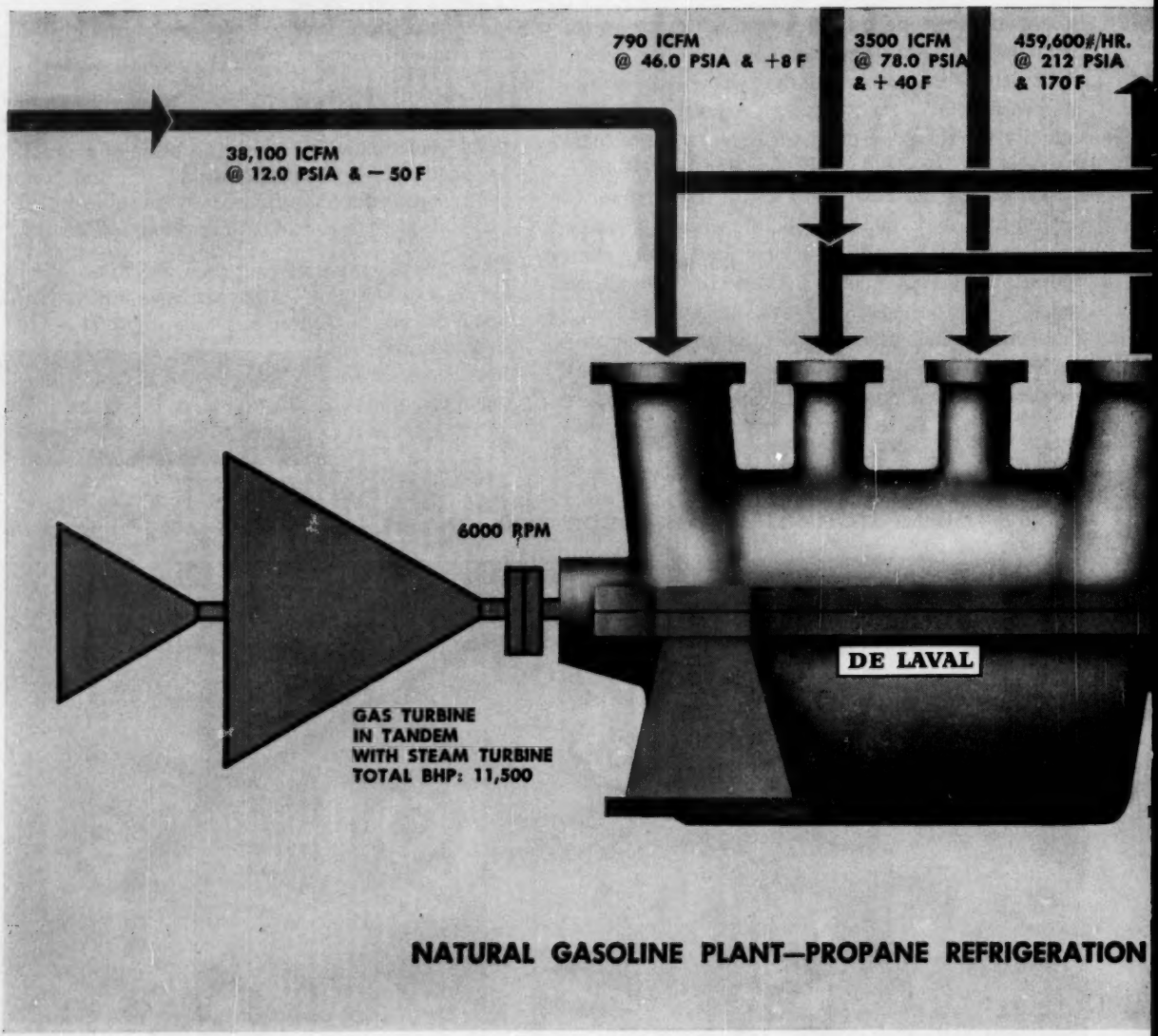
**RESISTOFLEX**
**CORPORATION**

*Complete systems for corrosive service*
***Plants*** **in Roseland, N. J. • Anaheim, Calif. • Dallas, Tex.**
***Sales Offices*** **in major cities**

*®Fluoroflex is a Resistoflex trademark, reg. U. S. Pat. Off.*
*®Teflon is Du Pont's trademark for TFE fluorocarbon resins.*

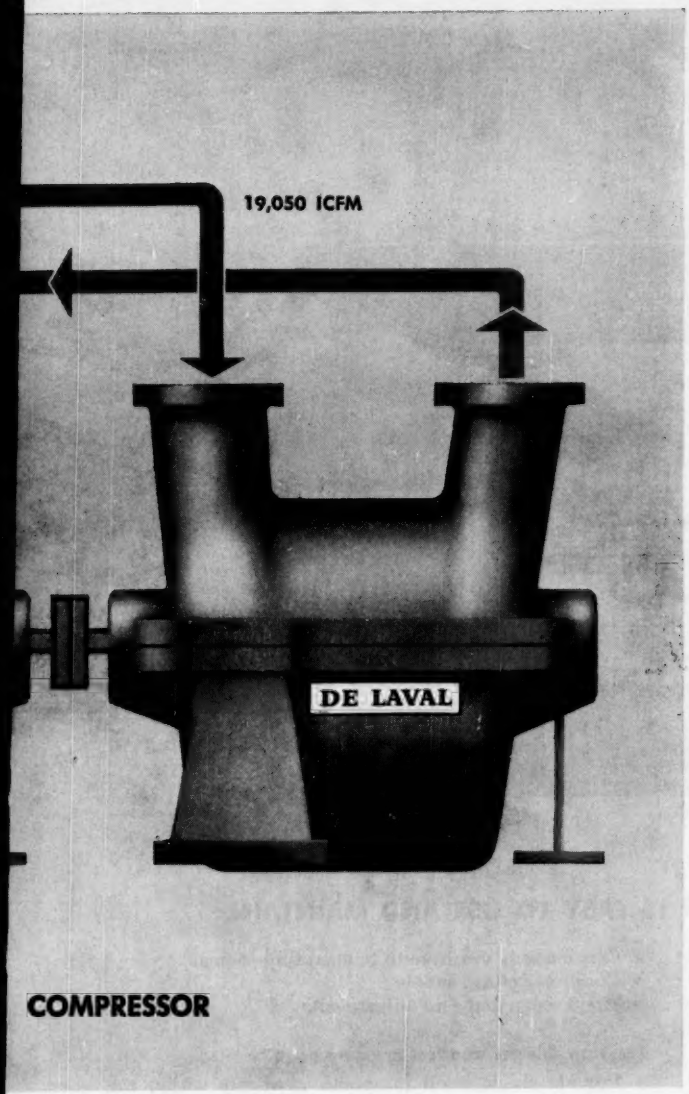

How complex is your drying problem?
FOR THE CHEMICAL PROCESS INDUSTRY: Stokes offers a complete line of vacuum dryers, atmospheric drum dryers and flakers, size reduction and tabletting equipment.

# Unique arrangement of compressors demonstrates




**NATURAL GASOLINE PLANT—PROPANE REFRIGERATION**

# centrifugal
# DE LAVAL design flexibility




Here is a good example of De Laval design flexibility. In this centrifugal compressor installation the customer wanted to use gas turbine drive because it would provide the most economical use of process fuel. But no single flow compressor design could operate at gas turbine speeds. De Laval creative engineering solved this problem by splitting the flow into two units and several stages as illustrated on these pages.

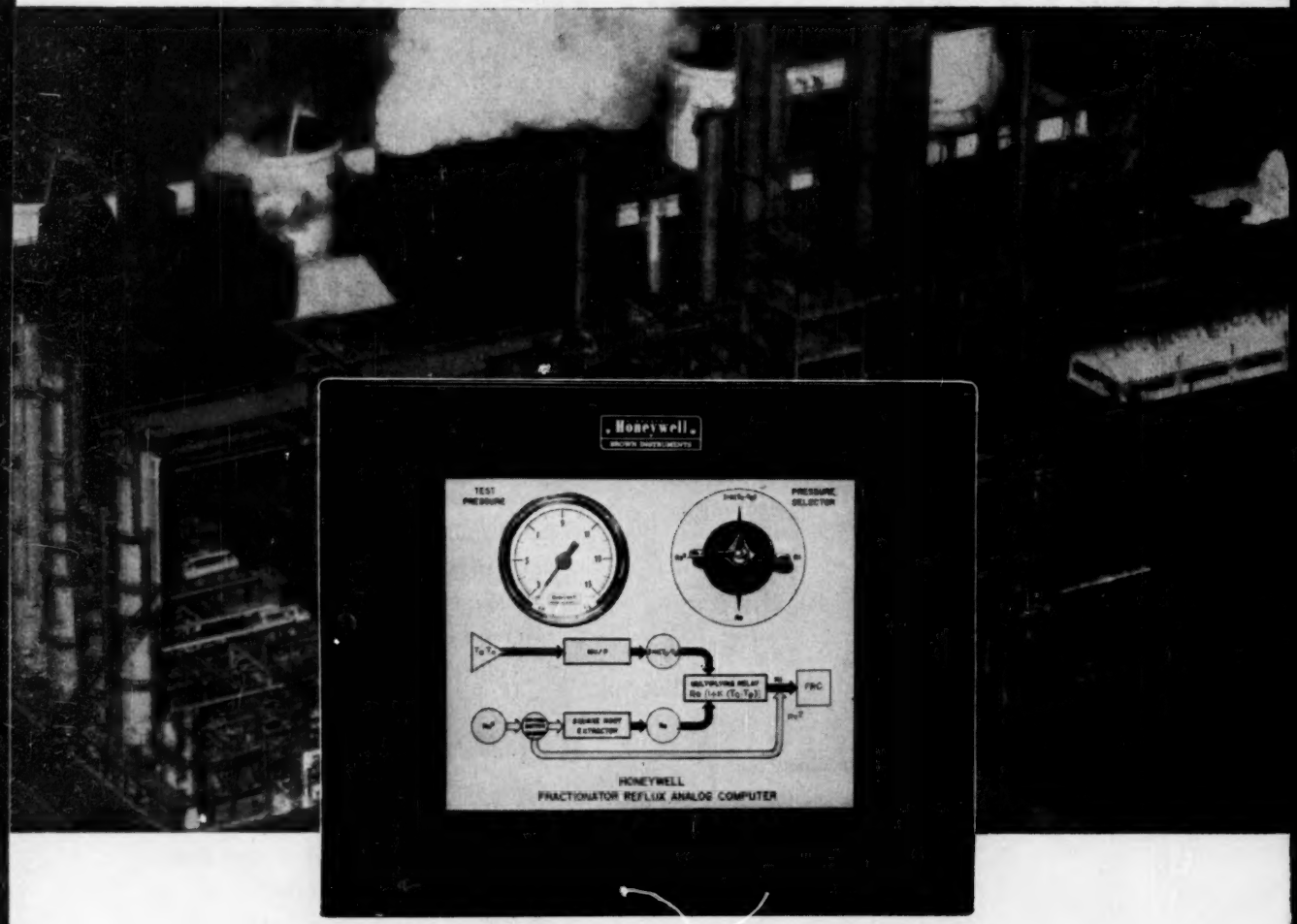
You can count on De Laval for flexible approaches to engineering problems. We have built high capacity and special purpose centrifugal compressors to meet the special requirements of the petroleum, petrochemical and chemical industries. Why not benefit by our more than 40 years of experience in solving gas compression problems?

***Send for De Laval Bulletin 0504.***

**DE LAVAL STEAM TURBINE COMPANY**
**803 NOTTINGHAM WAY, TRENTON 2, N. J.**

DL-231

# Stabilize Fractionating
## with new Honeywell




### HONEYWELL *FRAC* CONTROLLER IS EASY TO USE AND MAINTAIN

- Standard Honeywell components, packaged in a standard Honeywell strip chart recorder case—completely wired and internally piped.
- Only four simple, easily accessible process connections required to put the unit in operation.
- Chassis pulls out for front-of-case servicing, simplifying adjustment and maintenance for your instrument technicians.

**COMPONENTS**

**MV/P (millivolt-to-pressure) Transmitter**

- Fully transistorized
- Continuously sensitive to temperature change
- Constant voltage supply
- Simple span and zero adjustments

**Pressure selector and test pressure gage**

- Provide check of all pneumatic pressures within the computer for simplified trouble shooting.

**By-pass switch**

- Permits switching from *FRAC* control to conventional external reflux flow control.

# Column Operation

## *FRAC** Controller

- **Easily installed and maintained by present instrument technicians**
- **Savings realized justify installation**
- **Tamper-proof design**

This new Honeywell control system immediately adjusts column operation to the effects of ambient temperature on overhead product condenser and external reflux. It continuously computes internal reflux flow, to maintain the most efficient, economical fractionating tower operation.

The new method, originally developed and licensed by Phillips Petroleum Company, utilizes a simple Honeywell analog computer employing standard Honeywell electric and pneumatic instrument components.

By correcting instantly for temperature deviation, the new control system offers the following economies.

- Less reboiler heat is required, because large surges of internal reflux that would lower temperature are eliminated.
- Reduction in off-specification product minimizes re-runs and the need for intermediate storage.
- Closer control permits fractionator to operate closer to the flooding point.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

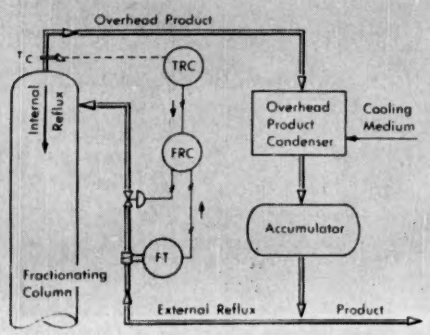
**Fractionator Reflux Analog Computer. Trademark, Minneapolis-Honeywell Reg. Co.*

from Honeywell... ANOTHER DIAMOND JUBILEE PRODUCT

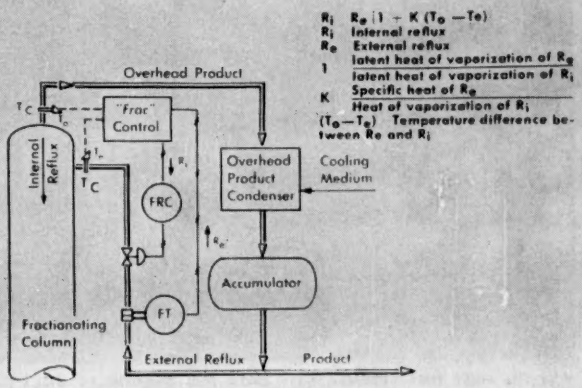
**Honeywell**

*First in Control*

SINCE 1885



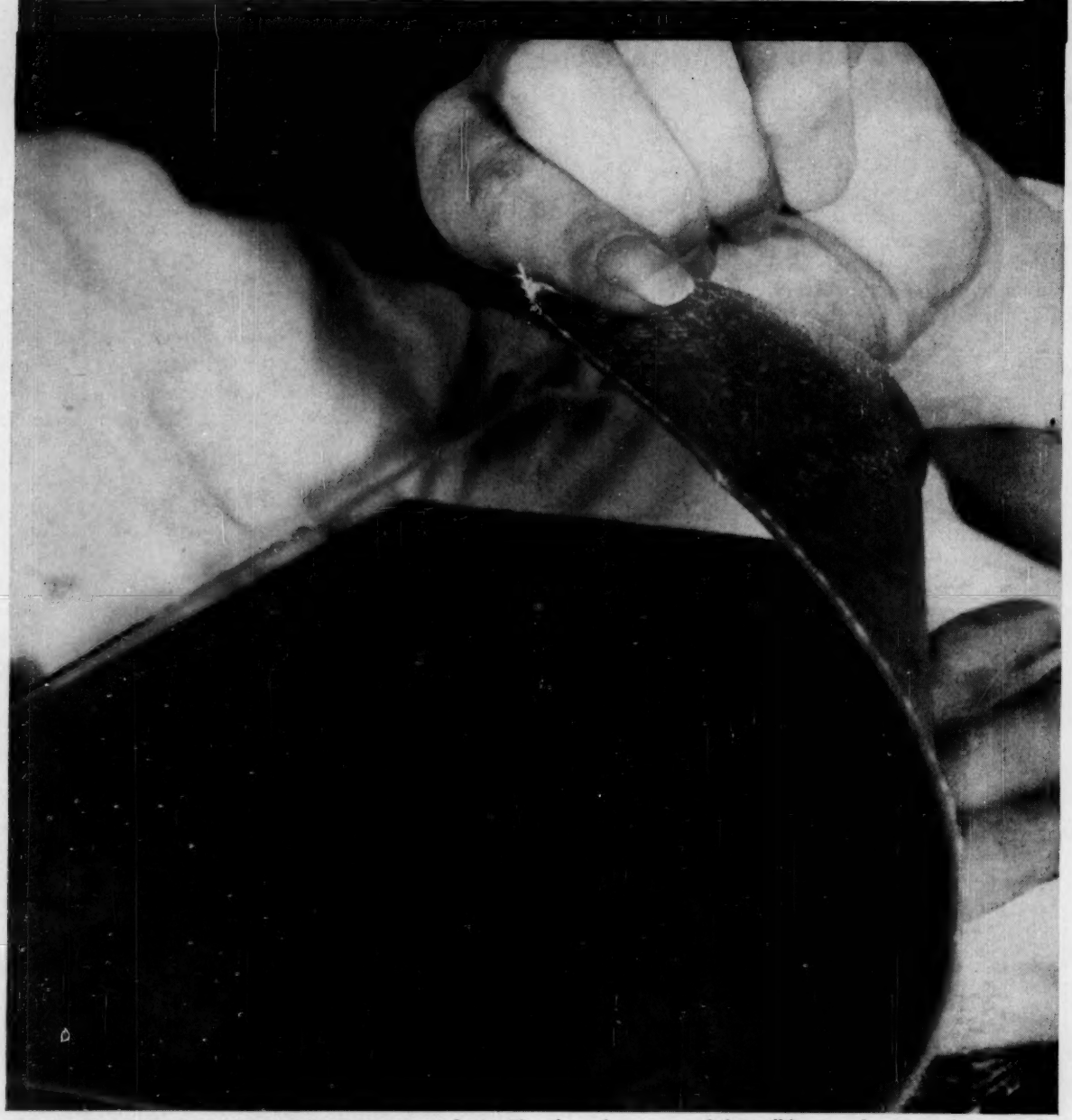

**PROBLEM with existing fractionator control systems—Column is upset when temperature of external reflux is indirectly affected by changes in atmospheric conditions or in the temperature of the cooling medium to the condenser. Result: off-spec product, wasted reboiler heat, lower fractionator capacity.**



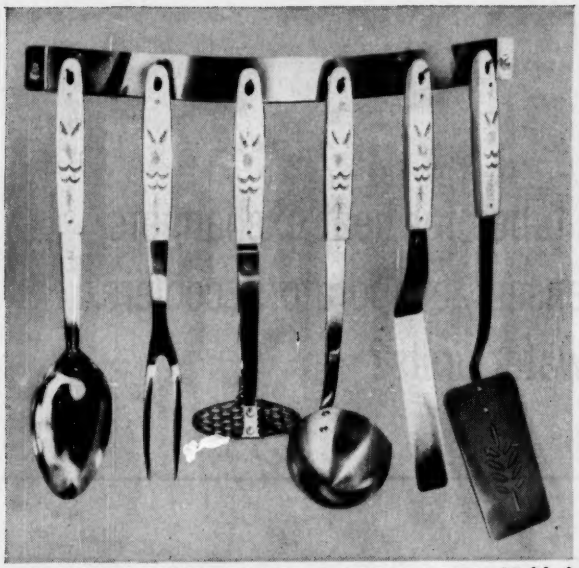

**SOLUTION: FRAC Controller (1) measures external reflux flow rate ($R_e$) and the temperature difference between the overhead product (To) and the external reflux ($T_e$); (2) computes internal reflux flow rate ($R_i$); and (3) holds it constant by adjusting external reflux flow rate for efficient fractionator operation.**

CYANAMID

# Chemical Newsfront



**FOR THE FIRST TIME—PERMEABILITY DATA FOR CYANOGUM® GEL.** The photo shows some of the well-known advantages of Cyanamid's CYANOGUM 41 gels: flexibility, ease of forming the gel, and rapid curing—only seconds at room temperature. Now, specific data are available to permit comparison of the CYANOGUM system's permeability with that of other well-known gels—viz agar, gelatin and silica. Are you interested in permeability coefficient and average pore size as a function of polymer concentration and deductions about the mechanism of transport in the gel? A copy of the article containing fundamental data on permeability recently printed in the Journal of Physical Chemistry is available to you on request. Check the appropriate area on the coupon. **(Market Development Department)**



**DECORATED MELAMINE HANDLES—A FIRST FOR FLINT.** Molded CYMEL® 1077 melamine handles with beautiful decorations are now part of EKCO Products Company's Flint Cook and Serve Tools. A melamine impregnated decorative overlay becomes a permanent part of the contour handles, which are wearproof and washable. **(Plastics & Resins Division)**

**ANTI-STATIC AGENT KEEPS PRODUCTS DUST-FREE.** Cyanamid's CATANAC® SN anti-static agent prevents dust-gathering static charges on plastic, paper, glass and a wide variety of substances. Whether incorporated into the composition or applied on the surface, CATANAC SN means less "housecleaning" of sales items in displays and on shelves. Result? Brighter, cleaner products that sell readily. **(Intermediates Department)**

CYANAMID

AMERICAN CYANAMID COMPANY
30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

**BEAUTIFUL WOOD STAYS "LIGHTPROOF" LONGER.** The "screen" is one of Cyanamid's CYASORB® Light Absorbers. Efficient on a variety of woods, CYASORB is added to the coating to retard wood discoloration from the effects of ultraviolet rays. CYASORB does not migrate from the coating during exposure, thereby offering long-range protection to both lacquer and wood. **(Intermediates Department)**

For further information on products in this advertisement wire, or mail this coupon to: **CE-11**

AMERICAN CYANAMID COMPANY
30 Rockefeller Plaza, New York 20, N. Y.
Dept. 6362

Please send me additional information on

- ☐ CYANOGUM Gel
- ☐ CATANAC SN
- ☐ CYMEL 1077 Melamine Molding Compounds
- ☐ CYASORB Ultraviolet Absorbers

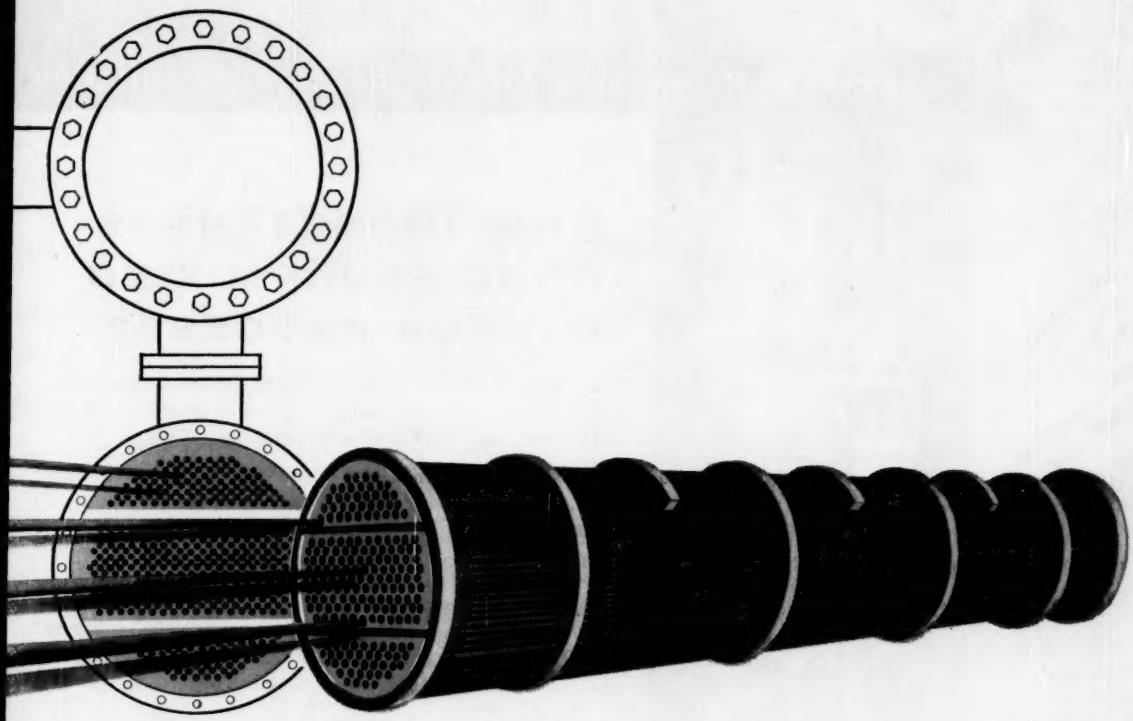
Name_____

Company_____

Position or Title_____

Address_____

City_____ Zone_____ State_____



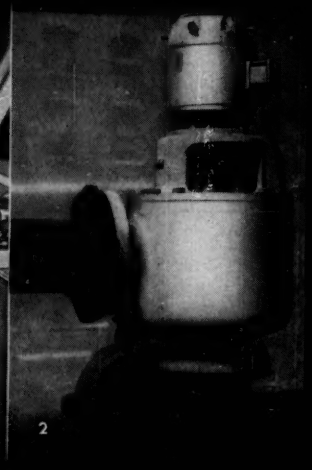
# reputation for reliable "On-Stream" Performance!

**Expert engineers** to help you solve tube corrosion problems, select the exactly correct alloy for your applications.

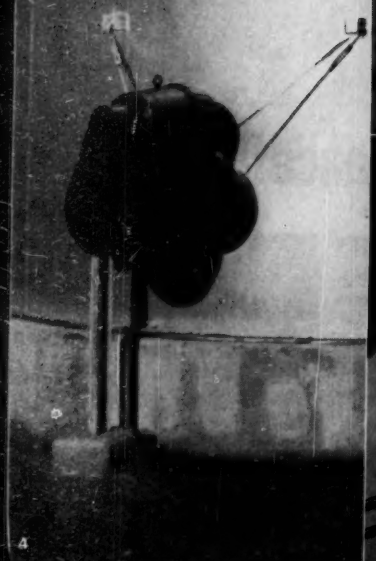
Specify the best—at the same cost as the rest!

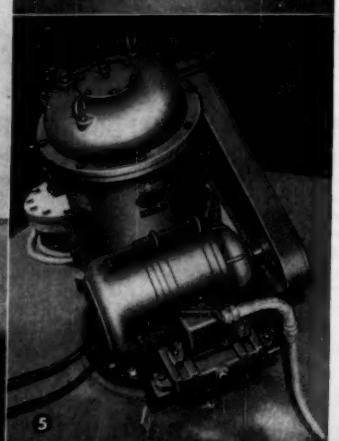
**PHELPS DODGE COPPER PRODUCTS CORPORATION**

**SALES OFFICES:** Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Dayton, Denver, Detroit, Fort Wayne, Greensboro, N. C., Houston, Indianapolis, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Tampa, Washington, D. C.



Improved Processing through Engineered Agitation





# HOW IMPORTANT IS GOOD FLUID MIXING IN YOUR PROCESS?

REGARDLESS OF HOW SPECIALIZED your particular processing needs are, good mixing can be the difference between "run of the mill" and maximum yields.

NETTCO MIXERS ARE PROCESS-RATED for optimum performance. Your particular process requirement is fully evaluated. And—it costs no more to get the full benefit of Nettco's wealth of agitation technology and broad application experience. Then—from design and pilot test to full process conditions, standard components are precision teamed to provide you with a Nettco mixer to meet your most exacting conditions. If good fluid mixing is vital to your process, then Nettco Engineered Agitation is vital to *you!*

PUT NETTCO ENGINEERED AGITATION TO WORK FOR YOU. From a full line . . . side drive, tank top, portable or tripod and unique continuous pipeline mixers, NETTCO can provide the answers to a wide range of mixing problems. See your NETTCO representative listed in Chemical Engineering Catalog or Refinery Catalog, or write for Bulletin 581, NETTCO CORPORATION, 87 Tileston Street, Everett 49, Mass.

**NETTCO**

**ENGINEERED AGITATION SPECIALISTS**
**EVERETT 49, MASSACHUSETTS**

1. Paint blending with Nettco tank top mixers on 400 gallon portable tanks.
2. Nettco Flomix® in the continuous recycling of waste product to improve yield.
3. Variable speed pilot plant application of Nettco medium speed, propeller drive mixer.
4. Raw material batch blending with Nettco side drive mixer to assure uniformity.
5. 15 year old Nettco tank top mixer for synthetic rubber production with one of first double mechanical seals.

# Don't Price Yourself Out of the PLUS Features You Get with SQUARE D CONTROL CENTERS

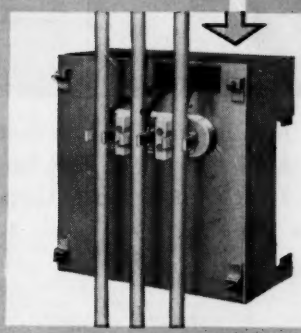
**Industrial construction**
All outer surfaces and structural parts are 12 gauge steel. Corner channels, cross members and doors are *formed* on special dies for maximum rigidity. Rust-resisting finish—phosphatized plus *baked* enamel.

**Saves space**
Unit heights in *3-inch* increments—an exclusive Square D advantage which permits use of units with minimum heights, eliminates the wasted space typical of modular systems.

**Built-in safety**
Units are metal-enclosed to confine damage should a fault occur. Unit side plates are permanently attached—can't be accidentally discarded. Switch-type units have visible blade disconnects for added safety.

**Extra control flexibility**
A variety of removable panels accommodates up to four oil-tight push buttons and pilot lights.

**Tubular vertical buses**
Another Square D "exclusive"—inherently stronger—greater cooling surface. Extra-wide spacing between phases gives added "breakdown" protection. Plug-in stabs are silver-plated copper backed by steel springs—give high pressure low resistance contact at all times.



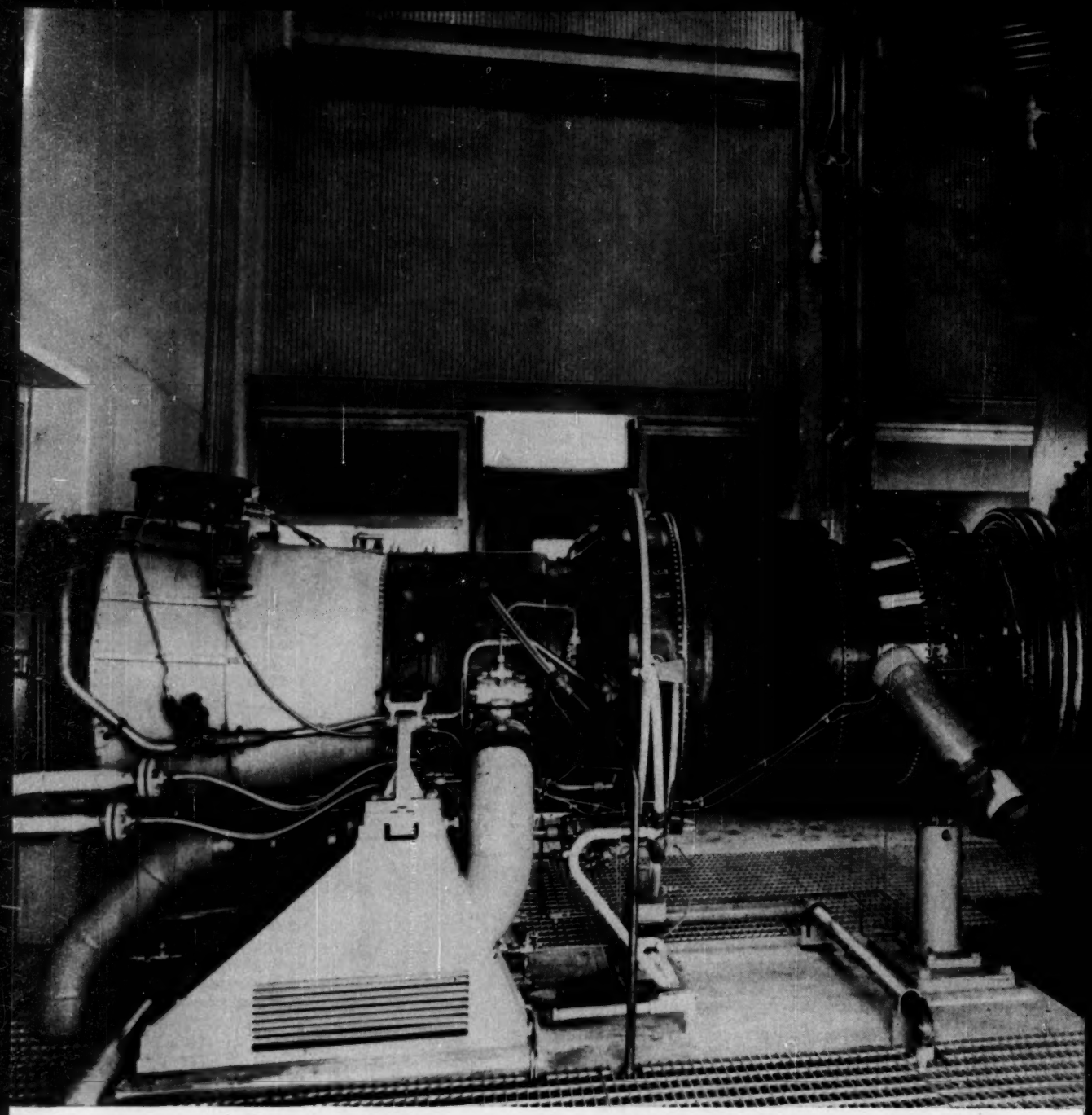
**Liberal wiring space**
Wiring channels are *large and accessible*. No wire fishing through narrow passageways—wires can be laid in position—less costly installation.

## GET THE COMPLETE STORY

**BULLETIN SM-244** gives detailed information on all of the "plus" advantages you get when you specify Square D motor control centers. Send for a copy. Square D Company, 4041 North Richards St., Milwaukee 12, Wis.

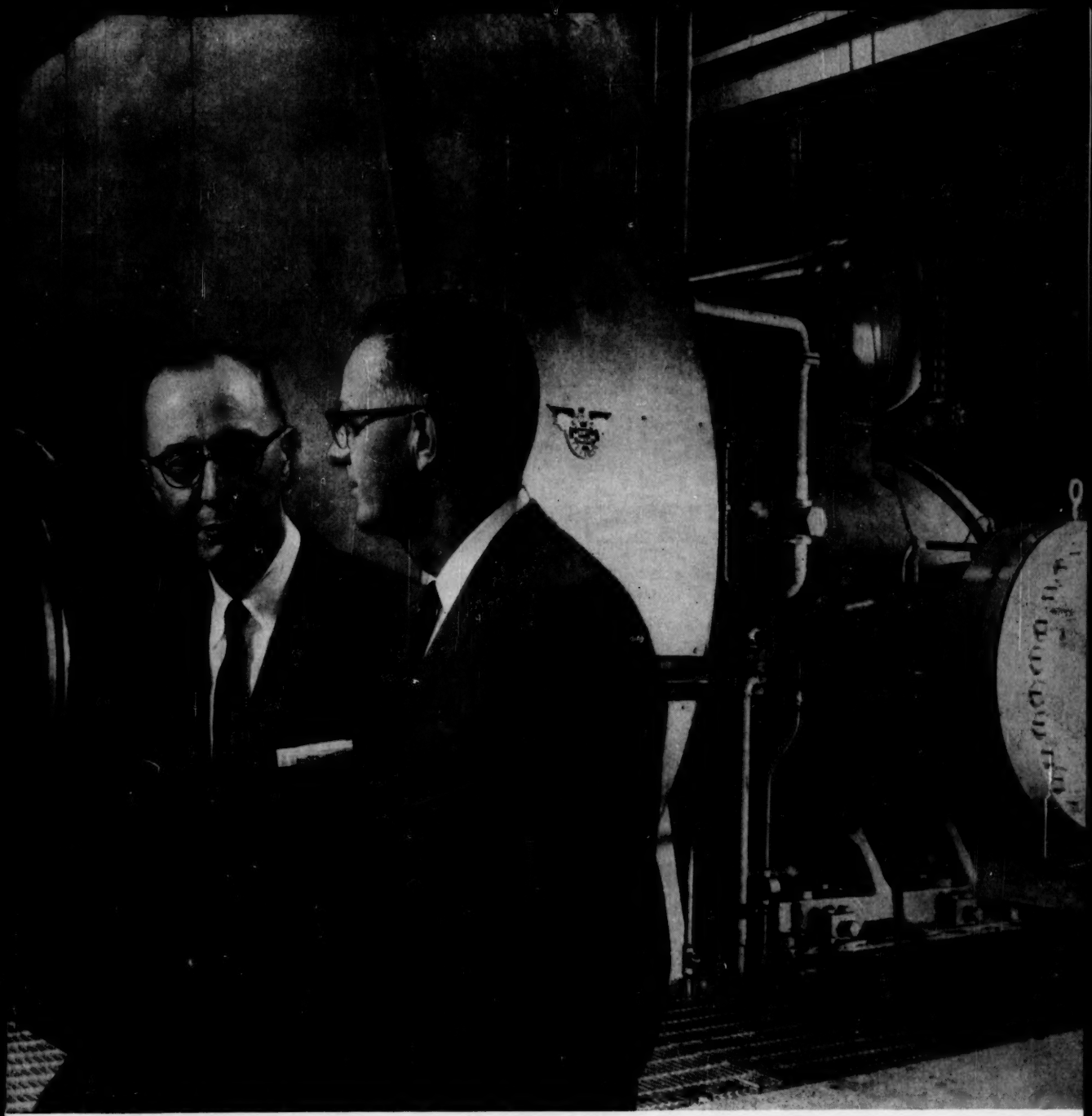
SQUARE D COMPANY

*wherever electricity is distributed and controlled*



R. L. Boyer, *Vice President and Director of Engineering, and* W. B. Boyum, *Manager of Gas Turbine Sales, The Cooper-Bessemer Corporation report . . .*

# World's first jet powered gas turbine is now on the job



YOU are looking at a revolutionary new concept in industrial power. This Cooper-Bessemer 10,500 hp RT-248 gas turbine with a modified J-57 aircraft jet engine introduces new, drastic economies in plant construction, operation and maintenance. Shown here on the job at the Clementsville (Kentucky) Compressor Station of Columbia Gulf Transmission Company, this powerful, compact unit has taken on the total gas-boosting load of the station, operating 'round the clock. Find out how this outstanding joint development of Cooper-Bessemer and Pratt & Whitney Aircraft can fit into *your* plans for compressors, generators and other rotating machinery. Call our nearest office.

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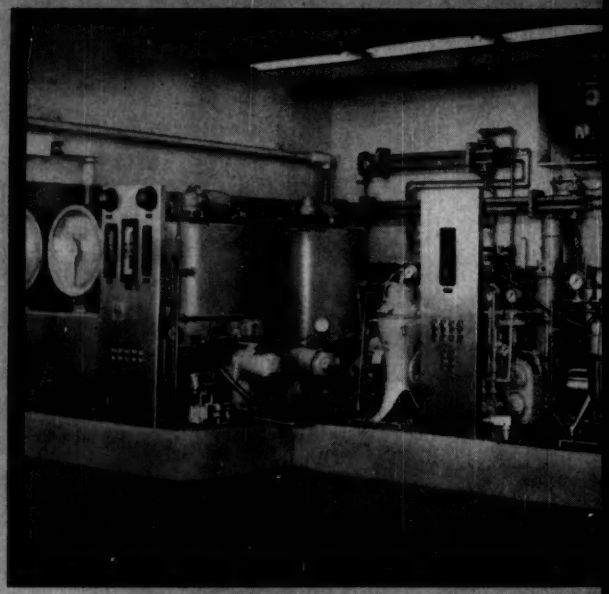
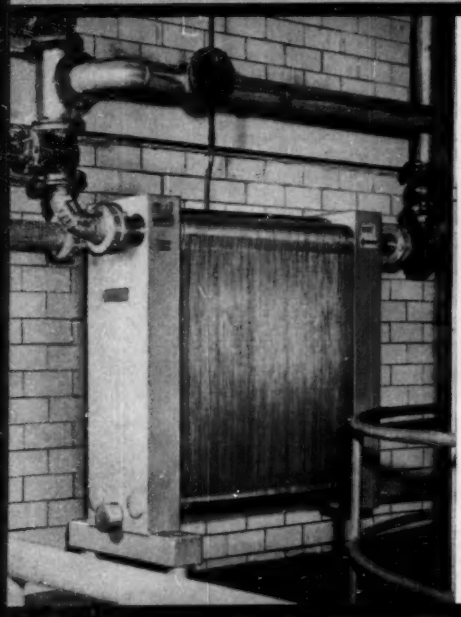
ENGINES: GAS - DIESEL - GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE, TURBINE OR MOTOR DRIVEN

# De Laval tackles process problems



## ...economically!



### How much do your Btu's cost?...and cost!

Your loss every time a pound of product stream cools 1°F is the cost of putting one Btu *into* the process. Multiplied by yearly stream weight and total temperature drop, this usually becomes a hefty figure.

Where conventional heat exchangers have been considered and found wanting, De Laval Plate Heat Exchangers may do the job of reclaiming this costly energy loss. Here's why:

- Stainless steel construction solves almost all corrosion problems – or assures sanitary operation.
- Extremely high heat-transfer efficiency and the compact packing of the corrugated heat-transfer plates means that a very small unit can do the job in very limited space. Wall-mounted De Laval PHE's even eliminate floor space requirements.
- Cleaning is unusually easy. Where the polished steel construction and induced turbulent flow don't eliminate cleaning, the plates are opened for inspection and scrubbing by a simple release mechanism.

Whether it's sulfite liquor, orange juice, latex, honey, detergent, milk, slurry, beer – or what have you – there's some real Btu money to be saved with a De Laval Plate Heat Exchanger. Write for details.

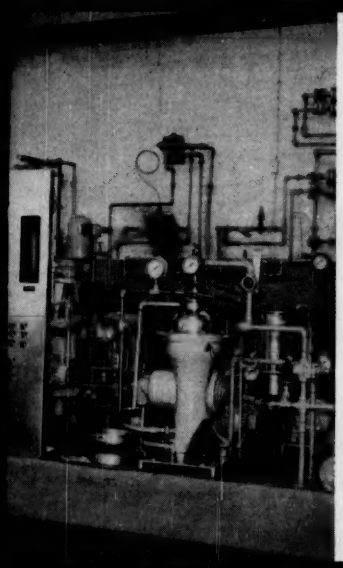
For Further Information Write To Dept. C-1

**DE LAVAL**

THE DE LAVAL SEPARATOR COMPANY
Poughkeepsie, New York
5724 N. Pulaski, Chicago 46, Illinois

DE LAVAL PACIFIC COMPANY, Dept.
201 E. Millbrae Avenue, Millbrae, Calif.

CENTRIFUGES
PLATE HEAT EXCHANGERS
VIBRATING SCREENS
COMPLETE PROCESSES



## On your samples or production quantities . . .

. . . we can perform trial centrifugal separations. Not only do we determine the most practical method, but we also obtain operating data useful for process design and operation. The De Laval pilot plant is equipped with the mixing, heating and reaction equipment necessary to do a comprehensive pilot plant evaluation. Your separation problem is sensibly related to your entire process.

Available is a wide working range of pressure, temperature and flow rate. De Laval engineers who are intimately familiar with the full potential of this well-equipped pilot plant will work with you – and work on your process problem. You benefit from their experience – and from the knowledge that any De Laval separator that is recommended incorporates (75) years of manufacturing know-how.

Give De Laval a crack at your current problems – or let us review some of those that you have uneasily considered "solved."

## THE FIRST 75 YEARS ARE THE HARDEST!

"Just 25 years ago — on our 50th anniversary — we might have thought that by this time we had solved every processing problem. Not so, of course. Every year brings new challenges and today we are developing, and making practical, new processes which were considered 'impossible' a quarter century ago. This work usually initiates in our well equipped pilot plant discussed above. In it, our 75 years of experience are at your disposal."

**Fred Wheelwright, Industrial Sales Manager**

## Shakes the product . . . not the plant!

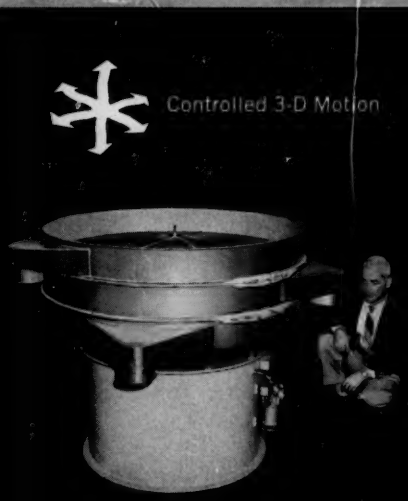
It sits on the floor, but directs its motion to the screens and the product – *not* to your floor beams. Abrasive crystals, soft foodstuffs, dry granules or liquid slurries are all efficiently screened or classified by De Laval's smooth-operating Syncro-Matic screen separator.

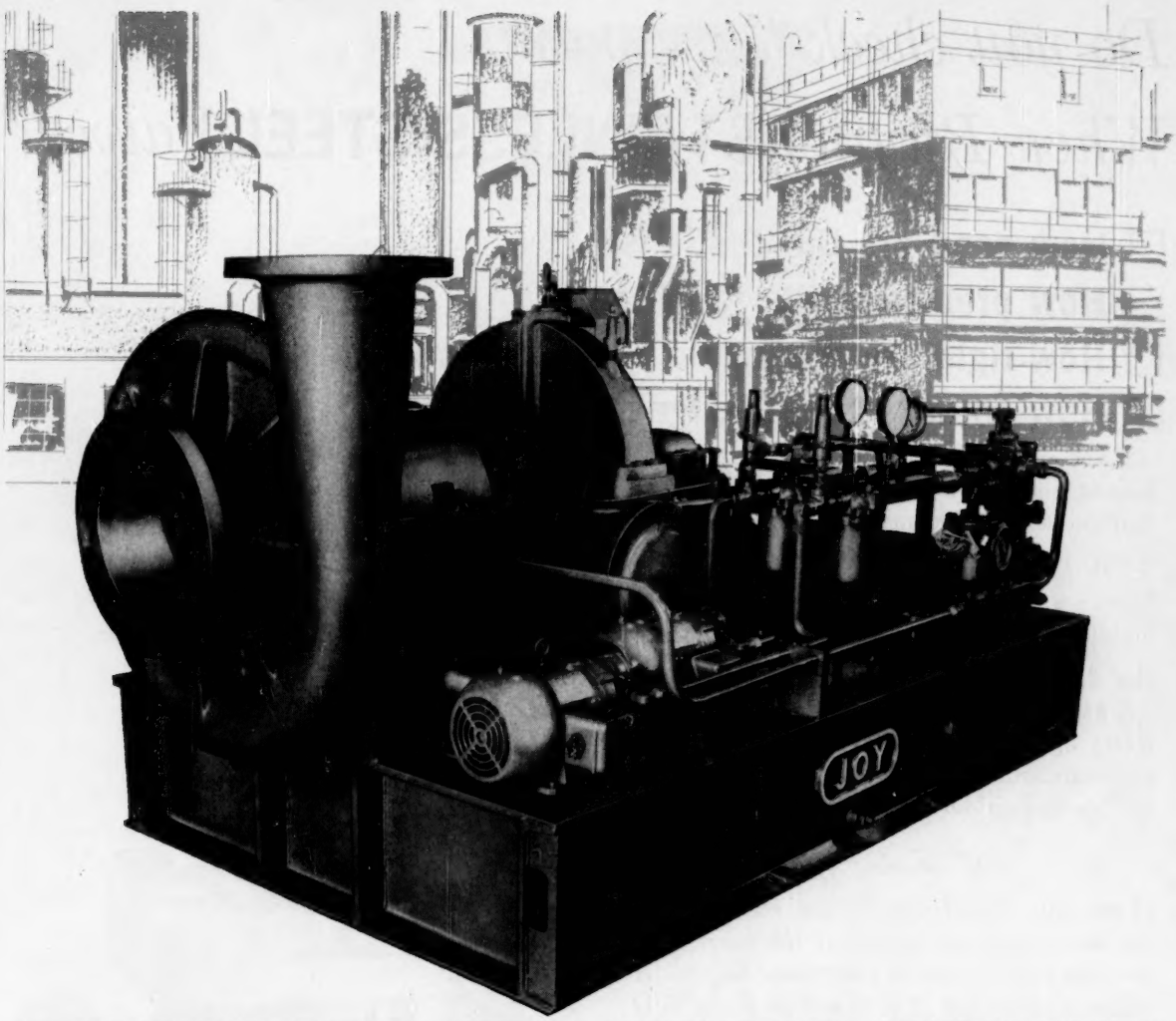
The secret is *direct* drive that can be easily adjusted independently for frequency and amplitude. This gives a controllable motion ranging from gentle classification of soft materials to turbulent high-throughput classification of, for example, mineral powders. The action is so efficient that a one horsepower motor does the job. Another great advantage is that the direct mechanical linkage assures a constant classifying action that, unlike gyratory types, does not dampen with heavy screen loading.

**Some applications are:**

- Wet-mill removal of starch from corn fibers.
- Dry grading of sugar crystals.
- Removal of pollution solids from waste streams.
- Scalping of liquid suspensions prior to centrifugal separation.
- Thickening of wood pulp slurry.
- Classification of resin molding powders.
- Removal of spent grain in fermentation.

The De Laval Syncro-Matic offers single, double or triple decks of plain or composite screens in a full range of commercial meshes and materials. Let us send you data.





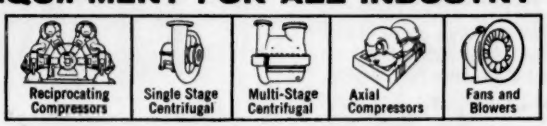

# JOY MODEL "G" SINGLE-STAGE CENTRIFUGAL COMPRESSORS PROVIDE THE UTMOST IN RELIABILITY

Joy Model G Single-Stage Centrifugal Compressors are designed and built to service continuous processes with the utmost reliability. They have a minimum number of bearings and no high speed couplings. Impellers are machined from a single piece of metal, and the entire compressor is ruggedly built.

Model G Compressors are not only reliable and maintenance-free, they also are highly efficient and very compact. They take less than half the space occupied by units of comparable output. Good aerodynamic design permits a reduction in scroll size, and use of an integral gear further reduces size and weight of the unit. Compressor and drive are mounted on a single base plate.

Model G Compressors are available in 6 models with capacities from 500 to 15,000 cfm—at 3 to 20 psig. on air service. For handling gases, special construction, materials and seals can be provided. Joy can also furnish reciprocating, multi-stage centrifugal and axial flow compressors to handle any air or gas compression requirement of the chemical processing industry. For full information on the Joy Model G Centrifugals, write for Bulletin 2468-11.

**AIR MOVING EQUIPMENT FOR ALL INDUSTRY**




**JOY**

**Joy Manufacturing Company**
**Oliver Building, Pittsburgh 22, Pa.**

**In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario**

# *Do you check these points When Buying* **STAINLESS STEEL** *Valves?*

- ☐ **How good are the castings?**
- ☐ **How precise is the machining?**
- ☐ **How rigid are the inspection and testing?**
- ☐ **How sound is the design?**

Just as important as a suitable stainless steel alloy are these four checks on valve quality. For long, dependable performance, a valve should rate *perfect* on every one.

There's a very good reason why you can be sure Jenkins Stainless Steel Valves will do that, unvaryingly:

For almost a century Jenkins has specialized in making valves. And making them to one standard of quality . . . the highest. Every operation and every worker is aimed at fulfilling that standard. The result is a product that can be backed by this 91-year-old assurance for valve users:

### *A Fair Offer*

*If you will put a Jenkins Valve, recommended for your particular service, on the worst place you can find . . . where you cannot keep other valves tight — and if it is not perfectly tight or it does not hold steam, oil, acids, water or other fluids longer than any other valve, you may return it and your money will be refunded.*


Order these reliable Jenkins Valves from your local Jenkins Distributor. Ask him or write us for Stainless Steel Catalog No. 59SS. Jenkins Bros., 100 Park Avenue, New York 17.

**JENKINS VALVES**

LOOK FOR THE JENKINS DIAMOND

JENKINS SINCE 1864 Jenkins Bros

*Sold Through Leading Distributors Everywhere*

# PUMP MAINTENANCE... as simple as this?

**A wad of waste is usually all that's needed to keep a Deming pump at top performance for years. Some people don't even bother to wipe 'em!**

Dependable Demings save you money in other ways, too. When routine servicing is performed, spare parts inventory is light because Deming parts are standardized and readily interchangeable. Plant expansion is less costly because Deming pumps are designed for adaptation to your growth requirements.

Deming rotary and sump pumps, end suction and vertical immersion process pumps are of special interest to the processing industries. For complete descriptive literature, just mail the coupon.

THE DEMING CO.

187 Broadway • Salem, Ohio

Please send me catalogs on: (type)_____pumps

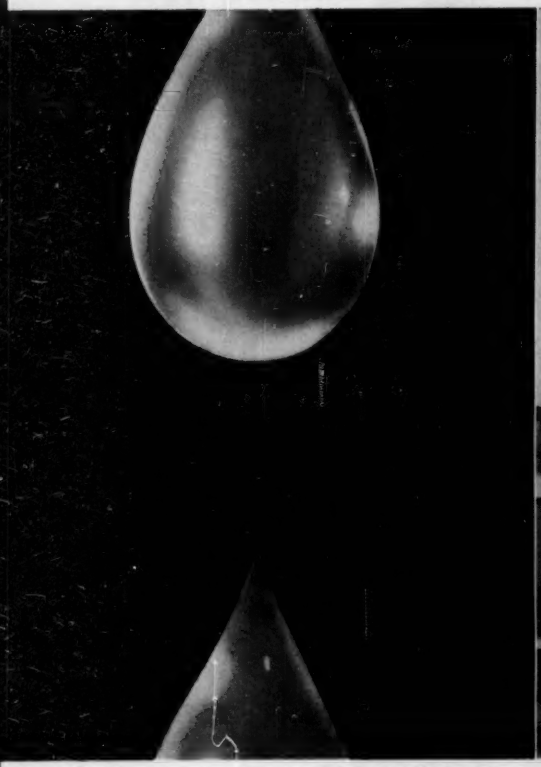
for (application)_____

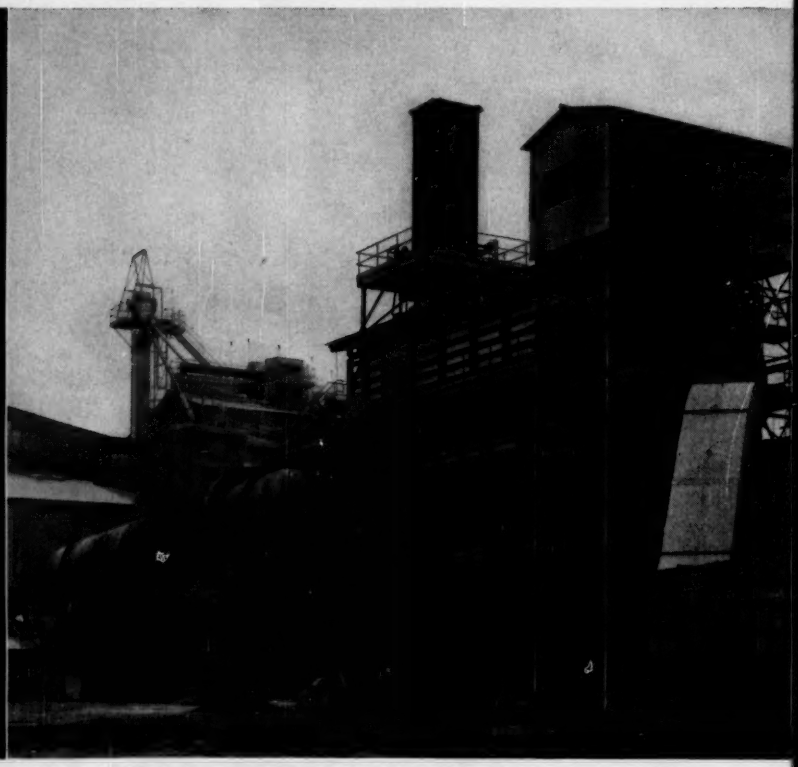
NAME_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

# ideas and news:





**Nothing leaks in... or out of Electri-Cand pumps:** Built without packing, stuffing box or seals, the pump-motor unit is completely fluid tight. Safely handles a wide variety of corrosive, toxic, and precious fluids without danger of contamination or loss. Liquid being pumped cools the motor, lubricates the bearings. Maintenance costs are low.

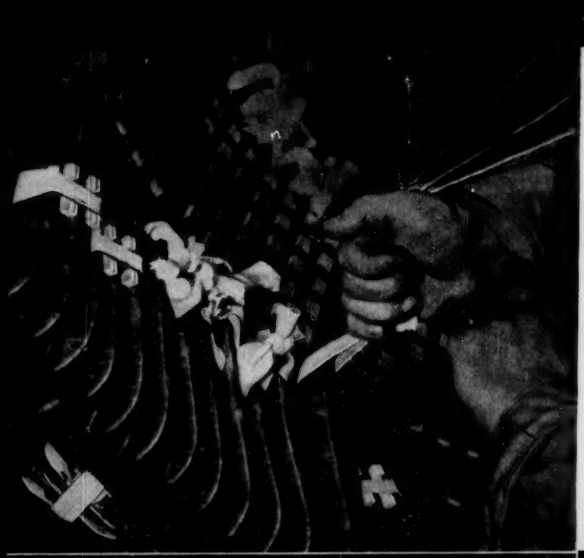
**More high quality lime — less fuel:** The Grate-Kiln System produces consistent high quality lime using 15% less fuel per ton of product than a conventional rotary kiln. Grate-Kiln Systems increase lime yield from limestone feed—outproduce conventional rotary kilns of the same overall length by 50%. Incorporated is a new high efficiency cooler which transfers maximum recuperated heat to secondary combustion air for kiln and preheater grate.

## Which of these productive ideas could be working for you?

A control unit that saves space. A pump that pumps practically any solution. These examples demonstrate the extra value that is a standard with A-C... the greater efficiency and the added productivity which are yours when you buy A-C products, systems and services. Call your Allis-Chalmers representative for details on A-C "worth-more" features. Or write Allis-Chalmers, Industrial Equipment Division, 907 South 70th Street, Milwaukee 1, Wisconsin.

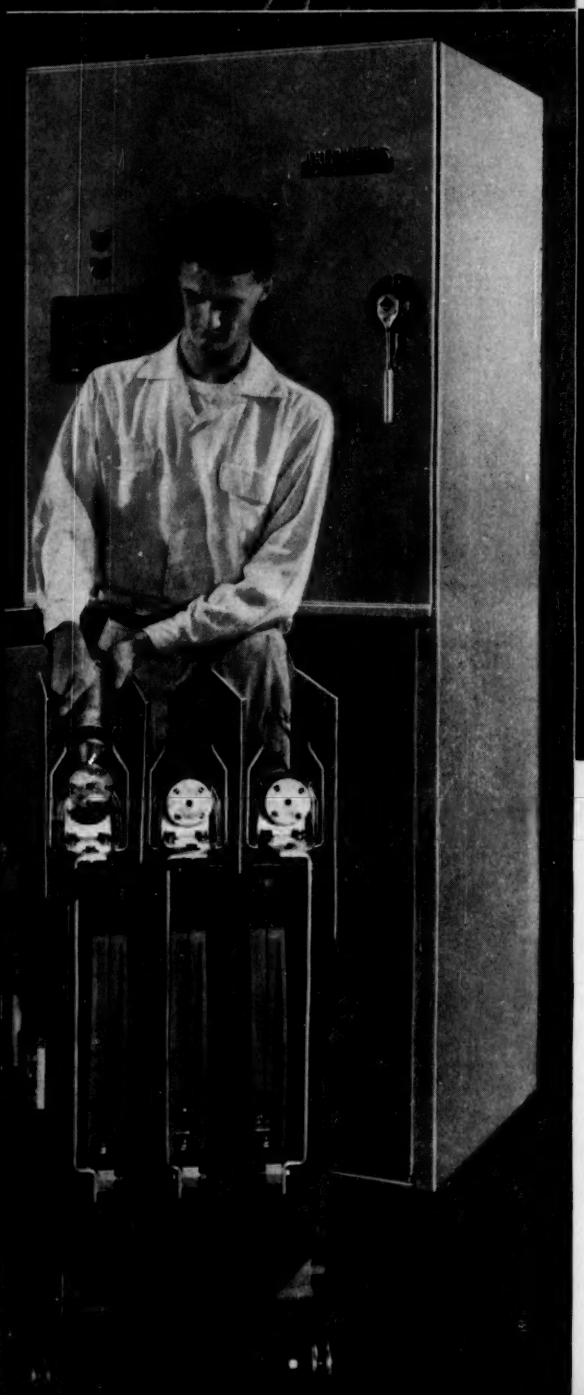
A-1404

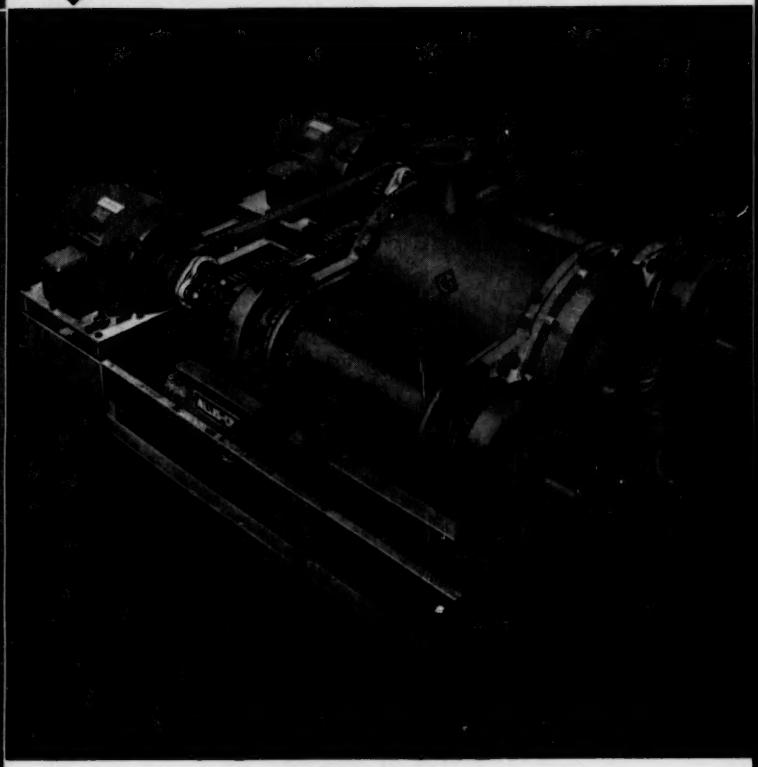
*Electri-Cand, Shelter-Clad, SpaceMaker, Pyro-Shield, Silco-Flex, Grate-Kiln and Compactor are Allis-Chalmers trademarks.*



**New coil insulation means fast service:** Here's downtime insurance you may never need. The Silco-Flex insulation system on large Allis-Chalmers motors is so superior that coil failure is highly unlikely in ordinary service. Should failure occur, the usual 10-day rewind shouldn't be necessary. Usually eight hours is enough for the entire job of replacing the coil.

**Compact, 30-inch vibrating mill:** Can actually outproduce a conventional tumbling mill 15 to 30 times per unit volume . . . is powered by just two 50-hp motors. Grinding media occupy 80% of mill's 12-cu.-ft. capacity, grind wet or dry materials as fine as two microns, as coarse as 48 mesh. Adaptable to grinding in inert atmosphere, can be utilized for closed or open-circuit grinding.





**So low, two fit where one used to go:** This new SpaceMaker control center is the first completely new 2- to 5-kv motor controller development in more than a decade. Two-high design can cut floor space needs in half. Full drawout construction makes it the safest, most easily accessible controller available. Flame-retardent, track-resistant Super Pyro-Shield insulation adds reliability. Walk-in Shelter-Clad enclosures available for outdoors.

**A-C INDUSTRIAL EQUIPMENT DIVISION:** motors, control, rectifiers, pumps, compressors, crushers, grinding mills, screens, kilns, coolers, dryers, Compactor mills, industrial systems.

**OTHER A-C PRODUCTS:** thermal, hydro and atomic electrical generating equipment, switchgear, transformers, unit substations, tractors, earth-moving equipment, engines, lift trucks.

# ALLIS-CHALMERS

# ECO ENGINEERING NEWS

*the big name in small pumps for the process industries*

## Pumping Notes

•

**Metering Melamine Resin Solution.** A Massachusetts paper mill uses Eco GEARCHEM Pumps to add melamine resin to paper stock to impart wet strength. Superintendent has found that continuous flow metering directly to the fourdrinier head boxes, with GEARCHEMs, offering ± 1 per cent reproducible accuracy, provides excellent results.

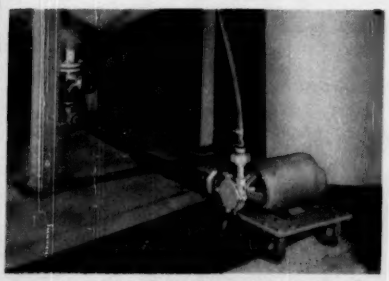
**Pumping Sulphuric Acid.** A South Texas cotton oil processor recently returned a CENTRI-CHEM Pump for its first complete parts overhaul after two years in sulphuric acid service. Is this typical of the life expectancy of this Carpenter 20 stainless steel pump in sulphuric acid service?

Life expectancy in chemical pumps is always a devious problem as slight temperature, viscosity, pressure or concentration changes can materially reduce or increase mechanical life. The above experience is average. Other CENTRI-CHEM pumps have been in operation in sulphuric acid service for about four years. Some have been short-lived due to misapplication on acid temperatures beyond the range for which Carpenter 20 stainless steel is recommended.

**Pumping Inhibited Styrene.** A large synthetic sponge manufacturer, utilizing inhibited styrene, selected the self-priming GEARCHEM Pump in 316 stainless steel for transfer of medium from drums to reactors.

**Pumping Calcium Chloride Brine.** A leading petroleum research laboratory found that it can best handle calcium chloride brine with an Eco GEARCHEM Pump in Hastelloy* B.

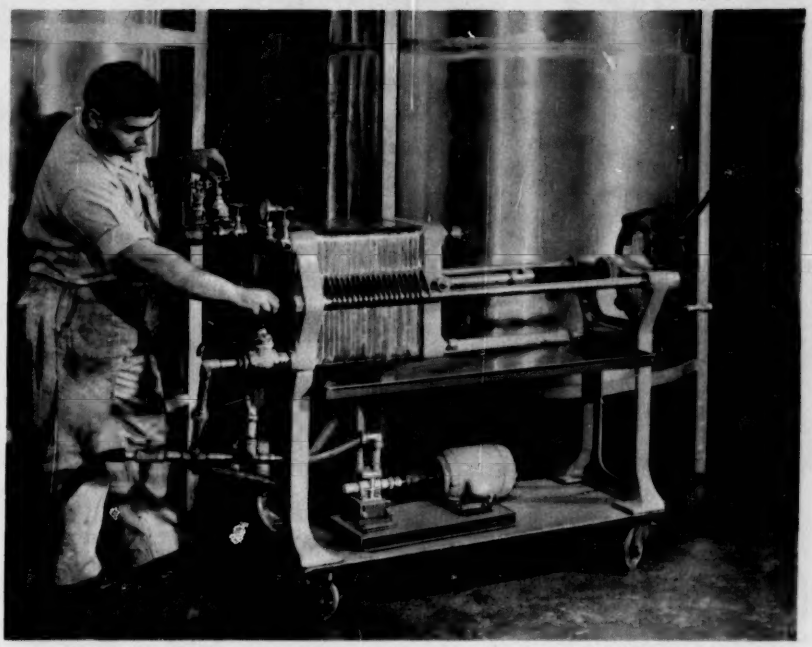
**Pumping Viscose Resin.** Polycarbonate resin in a chlorinated solvent vehicle, with viscosity of about 2450 SSU at temperatures from 50 to 200°F is successfully handled with a GEARCHEM Pump in 316 stainless steel with Hastelloy gears.



**Pumping Acid Solutions of Rare Earths.** Eco CENTRI-CHEM Pumps are dolly-mounted, moved from system to system as the cycle of operation progresses in these ion exchange installations at a mid-western processing plant.

**Union Carbide Trademark*

## Face Creams Can't Be Whipped



To facilitate use at many locations in batch processing, this ALL-CHEM Pump rides with the pressure leaf filter it serves. Dual manifold also permits by-passing the filter press for other pumping services.

Many of the materials and semi-finished products handled by Paris Cosmetics, Inc., in their manufacture of face creams, lotions, lipsticks, rouges, etc., for leading cosmeticians—could easily be whipped into unbelievable, unmanageable froths if pumped by ordinary equipment.

That is why Paris uses Eco ALL-CHEM Pumps with their linear, non-foaming flows, ideal for shear sensitive emulsions, in transferring all these compounds from one process to the next.

### Perfect for Filter Press

A typical use of these ALL-CHEM Pumps at Paris is pumping compounds from one holding tank to another via a pressure leaf filter. Maximum pumping rates are 10 gpm against low heads of approximately 12 psi.

### Handles Warm Waxes

Paris has found that the ALL-CHEM Pump is also ideal for pumping waxes at temperatures of 75° to 80° C. Other basic materials pumped include alcohols, glycerines, fatty acids.

### Portable Units for Batch Compounding

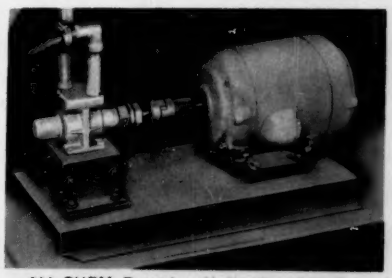
Process steps and materials vary with each product and customer specifications; hence compounding at Paris Cosmetics is, by necessity, a batch operation. For this reason, the ALL-CHEM Pumps are mounted as portable units so that they provide the greatest convenience and flexibility of use.

These pumps, like all other processing equipment and piping, are constructed of 316 stainless steel, with Teflon† impellers and bearings for positive, non-contaminating service.

### Pumps Withstand Abuse

Paris reports good service on all their ALL-CHEM Pumps, despite the continual hazard of abuse by mechanically inexperienced personnel. ALL-CHEM Pumps have been standard equipment at Paris Cosmetics since 1956.

†*du Pont Trademark*

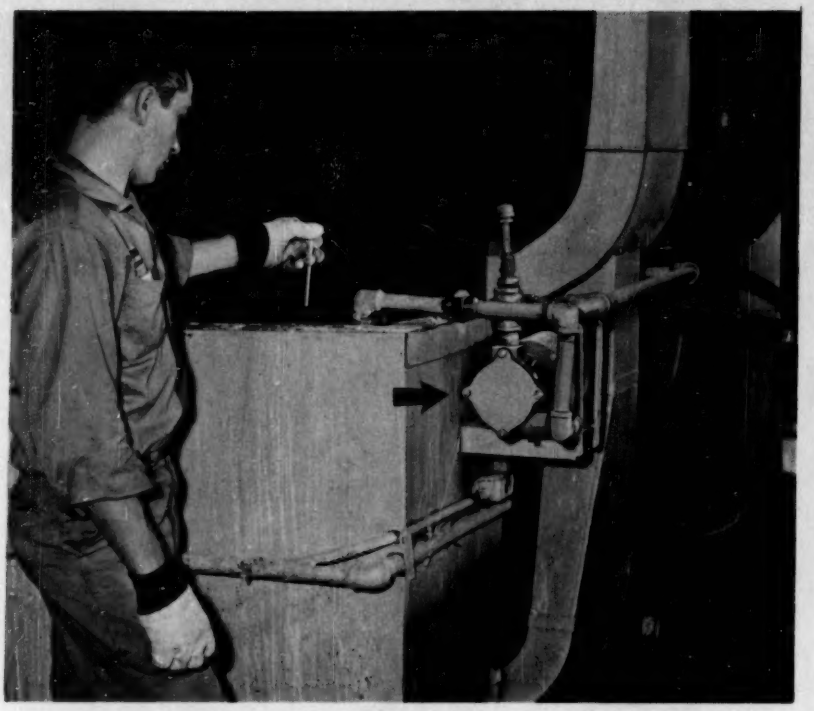


ALL-CHEM Pumping Units like this one have been in continuous service for periods up to 4 years with a minimum of repairs.

ECO ENGINEERING COMPANY · 12 New York Avenue · NEWARK 1, N.J.

# ECO ENGINEERING NEWS •

## More Power to NICAD Batteries



A temperature check of the potassium hydroxide bath at NICAD reveals that CENTRI-CHEM recirculating pumps have solved the problem of keeping uniform temperature throughout the bath.

Gould-National Batteries, NICAD Division, St. Paul, make the famous NICAD rechargeable sealed batteries, hailed by sportsmen and widely used in cordless electric shavers.

An important step in the production of these nickel-cadmium batteries is the impregnation of the plates by immersion in hot solutions of potassium hydroxide and nickel nitrate. In this process, temperature and concentration of the bath solutions must be kept uniform to insure uniform high quality to meet Gould-National standards, and reduce rejects.

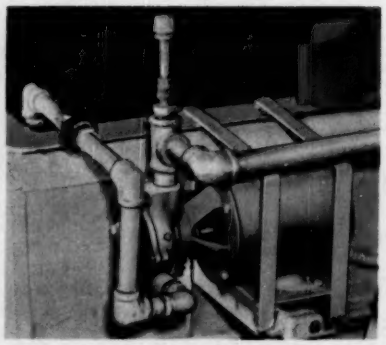
Simple immersion in static solutions was not satisfactory as stratification of the solutions presented varying temperatures and concentrations in different areas in the tanks.

To overcome this difficulty, Gould-National employs Eco CENTRI-CHEM Pumps of Carpenter 20 stainless steel to continuously recirculate, agitate and mix the hot corrosive bath solutions, without contamination of the media.

The CENTRI-CHEM Pumps draw the solution from the top of the tanks, which are heated by means of water jackets, and then pump it through a pipe manifold to the distribution nozzles in the bottom of the tanks.

The resulting turbulence assures uniform concentration and temperature of solution at every point in the tanks—hence all battery plates receive uniform exposure.

Results: fewer rejects, increased production, lowered costs, a uniformly better product.

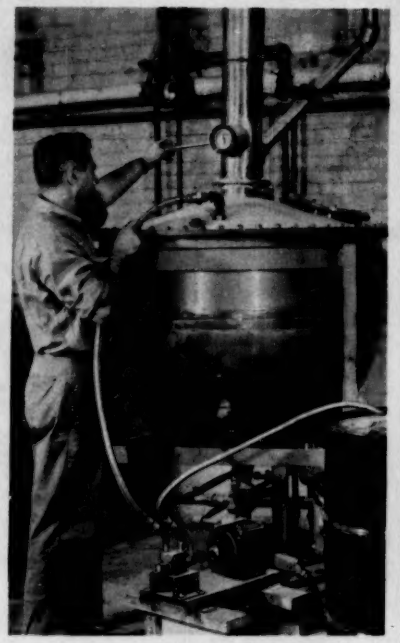


These non-contaminating CENTRI-CHEM Pumps of Carpenter 20 stainless steel throughout, recirculate hot caustic solution at the rate of 10 gpm in each immersion tank.

### ECO Products for Handling Corrosive and Hazardous Processing Fluids

**ALL-CHEM® Rotary Pumps**
**MINILAB® Rotary Pumps**
**GEARCHEM® Gear Pumps**
**CENTRI-CHEM® Centrifugal Pumps**
**PUMPMOBILE® Portable Pumping Units**
**GEAR-VAC® Valves**
**CHEMICAL DISPENSING VALVES**
**Factory Mutual Approved**

*Ask for literature on any or all of these ECO Products*



## Something to Get Your Teeth In

Acco Polymers, a division of Acralite Co., Brooklyn, N. Y., manufacture acrylic polymers used in the molding of dentures, which cure at low temperatures, without distortion, thus assuring superior fit and dimensional stability.

These American Dental Association approved materials—as well as other polymers, custom compounded to meet individual customer specifications—require extremely exacting processing procedure.

### Almost Pilot Plant Scale

Consequently, Acco's manufacture is quite different from that of other giant firms in the plastics industry.

Production is planned on almost a pilot plant scale and all equipment must meet exacting requirements of performance and dependability.

### Acco Selects Eco

Four years ago, Acco faced the selection of a pump type most suitable for their requirements in handling methyl methacrylate and other monomers from drums to reactor and to transfer intermediate liquids from reactor to evaporator or other process equipment.

The Eco ALL-CHEM Rotary Displacement Pump in 316 stainless steel with Teflon impellers, bearings and seals, was selected.

### Very Little Maintenance

Today, after four years of experience with this Eco Pump design, Acco is still highly pleased because, according to Mr. S. Rubinstein, plant manager, "It is a pump we can depend upon. It has never caused us any lost time in polymer production. It requires very little maintenance—only an occasional replacement of Teflon Bearings or packing."

ASK FOR LITERATURE

ECO ENGINEERING COMPANY • 12 New York Avenue • NEWARK 1, N.J.

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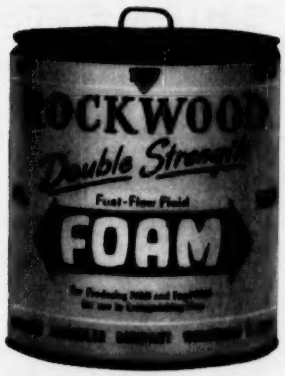


**ROCKWOOD SPRINKLER COMPANY**

*A Division of The Gamewell Company*
*Subsidiary of E. W. Bliss Company*

***Engineers Water*** *. . . to Cut Fire Losses*

**FOR FIRE FIGHTING** purposes Rockwood Double Strength FOAM is inexpensive and completely effective. 3 parts *Rockwood Foam Liquid, plus 97 parts free water, plus 900 parts free air give you a fast low-cost fire extinguishing agent for only 1½ cents a gallon!*

Rockwood Double Strength FOAM puts out fires fast . . . reduces your storage costs . . . reduces shipping costs too! If you're using other types of special hazard fire extinguishing agents — you may not be using the most economical or most effective agent! We'll show you how to save on training cost and on fire fighting costs — and to fight fires better! Send in the coupon below. Tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal cities.

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Please send me complete information on Rockwood fire-fighting products.

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*City*.....*Zone*....*State*.....


## RAIL AND WATER SHIPMENTS

**In order to better serve our far-flung customers in the process industries, we have developed at Beaumont, Texas the most modern Sulphur storage, handling and loading facilities in the world. This terminal and shipping center is now receiving deliveries from all four major TGS properties in Texas: Spindletop, Moss Bluff, Newgulf, and Fannett - the most recent mine to be developed.**

*. . . is now operating at* **Beaumont, Texas**

# THE WORLD'S NEWEST SULPHUR TERMINAL

*. . . for Solid Sulphur*

*. . . for Molten Sulphur*

***A few of the design features of this terminal may be of interest:***

- **It receives, stores, and loads both solid and molten sulphur.**
- **It can load simultaneously 1 dry cargo ship of 20,000 tons capacity, 3 molten sulphur barges and 1 molten sulphur tanker. There's a holding dock where a second cargo ship can be tied up. The barge basin will accommodate 12 sulphur barges.**
- **Storage capacity totals 31,000 tons for molten sulphur and 1,000,000 tons for solid sulphur. Loading capacity for molten sulphur ranges up to 3,000 tons/hour, tanker and barge simultaneously; for solid sulphur the loading capacity is 1,200 tons/hour into ship or barge.**

This development at Beaumont is but another step in the broadening delivery service program now being carried out by TGS. Regional distribution centers, handling molten sulphur, are already in operation at Cincinnati, St. Louis and Tampa. Coinciding with the full operation of our main terminal at Beaumont will be the opening early in 1961 of two coastal terminals at Carteret, New Jersey, (26,000 tons molten sulphur storage) and Norfolk, Virginia (20,000 tons). Other terminals are in the planning stage.

**TEXAS GULF SULPHUR COMPANY**
**75 East 45th Street, New York 17, N. Y.**
**811 Rusk Avenue, Houston 2, Texas**
*Sulphur Producing Units:* **Newgulf, Texas • Spindletop, Texas Moss Bluff, Texas • Fannett, Texas • Worland, Wyoming • Okotoks, Alberta, Canada.**

YARWAY

*from* **Yarnall-Waring Company,** *Philadelphia 18, Pa.*

*BRANCH OFFICES IN 19 UNITED STATES CITIES • SALES REPRESENTATIVES THROUGHOUT THE WORLD*
*STEAM TRAPS STOCKED AND SOLD BY 270 LOCAL INDUSTRIAL DISTRIBUTORS*

*The whole works—steam trap, strainer and blow-down valve—fit in the palm of your hand*

# ENTHUSIASTIC APPROVAL!

## INDUSTRY WELCOMES NEW SERIES 130 IMPULSE STEAM TRAP WITH OPEN ARMS

*"Radically new and different—send 50."*
TEXAS INDUSTRIAL

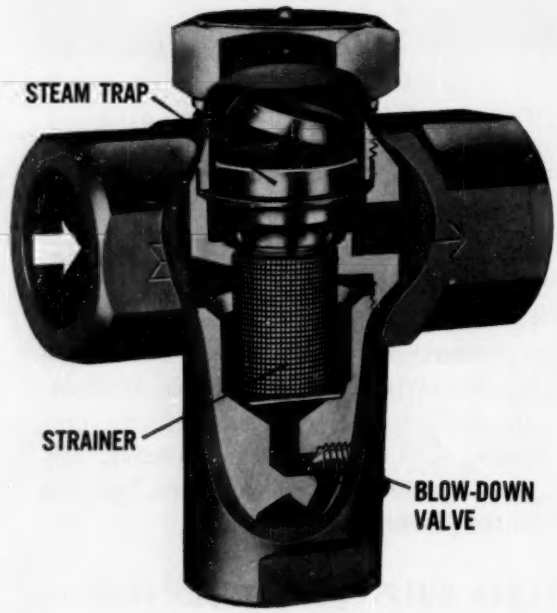
*"We want 100 immediately. They meet our confined space needs perfectly."*
WISCONSIN PACKER

*"Ordering 60 as first part of new standardization program."*
LOUISIANA REFINERY

*"We'll start with 24—more later."*
OHIO PETRO-CHEMICAL

So it goes—industry's welcome to the new Yarway Series 130 combination steam trap has been a warm one. Already manufacturing quotas have been doubled to meet the demand. Yarway distributors everywhere are busy answering their customers' requests for demonstrations.

What will the new Series 130 do for you? Consider these advantages:




## COMPACT COMBINATION SAVES SPACE, MONEY, MAINTENANCE ON LIGHT LOAD APPLICATIONS

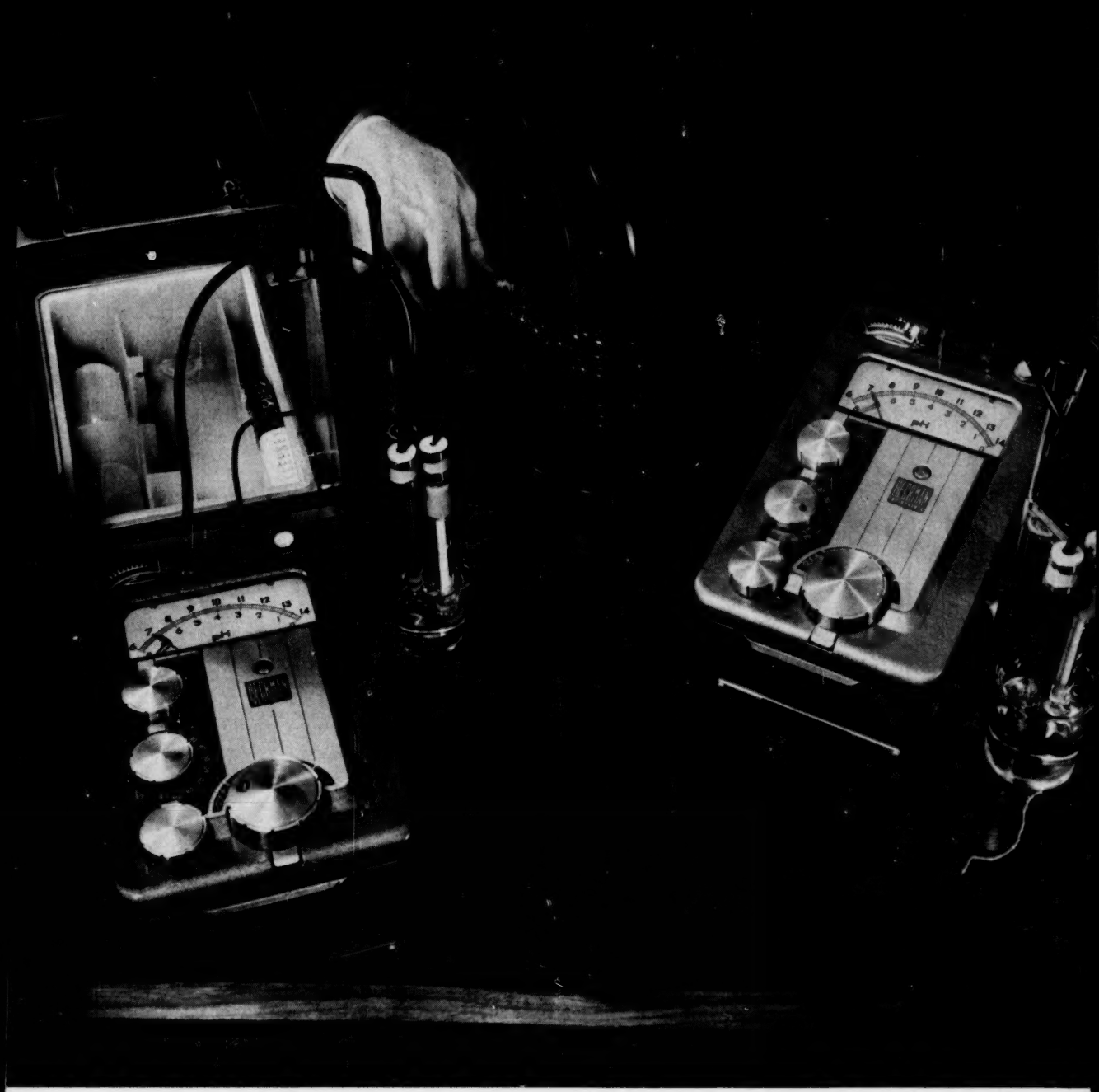
Steam trap, strainer, blow-down valve combination simplifies trapping hook-ups—saves up to 30% in time and materials over ordinary hook-ups.

### NO OTHER STEAM TRAP COMBINES SUCH COST-SAVING, WORK-SAVING FEATURES

All stainless steel construction, woven stainless steel strainer screen, replaceable trap valve-seat assembly, Allen wrench-operated blow-down valve—make maintenance easy.

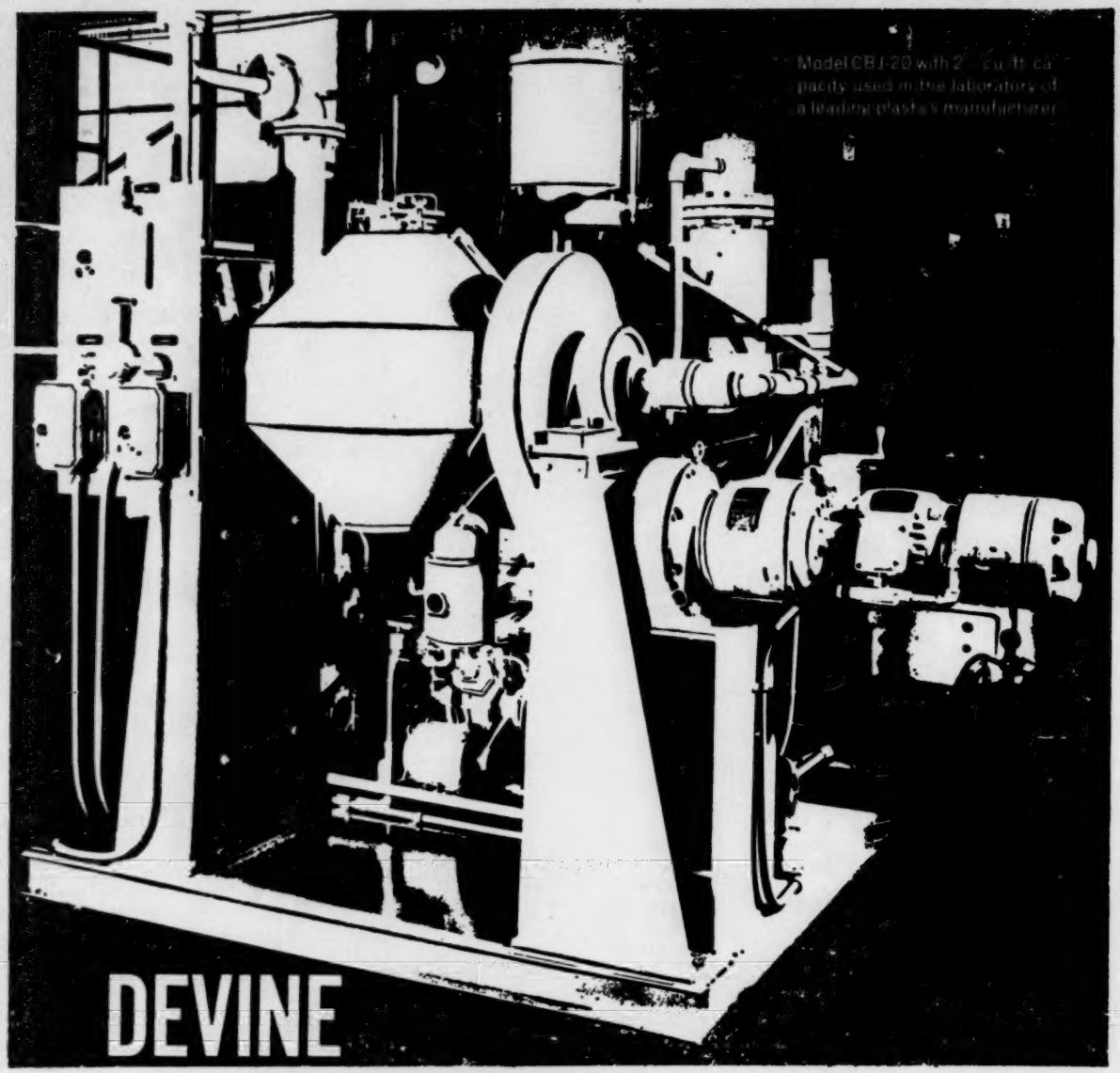
Small size, light weight, good for all pressures 8 to 600 psi—make installations simpler.

Try this trap on your steam main drips, steam tracer lines, meter boxes or any other of thousands of light condensate load applications. Call your nearby Yarway distributor today—or write us for more details.



*Circuit judges of the pH court*... recognized authorities in the field of electrometric measurement and control. Beckman pH meters have been rendering undisputed decisions for 25 years... ever since the first commercially available pH meter was developed by Dr. A. O. Beckman in 1935. ⌘ Pictured at the left, the portable Model N-2 is the "circuit judge" of field determinations and arbiter of accuracy for permanent plant pH installations. At the right, Model N-1 is more likely to be found on the bench in laboratories and plant use everywhere. ⌘ Both the N-1 and N-2 are easy to read, accurate to 0.1 pH, with reproducibility to 0.03 pH units. Less than 10 seconds warmup is required to provide readings over the full 0-14 pH range; 0 to ± 420 millivolts. Battery operated, they may be used with grounded systems, and are temperature compensated from 0 to 100°C. Both rugged models are supplied with a complete complement of basic electrodes and other essential equipment. ⌘ In any case of pH analysis and control it's good judgment to get full technical details and specific application information from your Beckman laboratory apparatus dealer or field office. Or write to us for Data File 14-4-01.

**Beckman**
*Scientific and Process Instruments Division*
*Beckman Instruments, Inc.*
*2500 Fullerton Road, Fullerton, California*




# CONICAL DRYERS Combine Operations and Cut Costs

Designed to mix and vacuum dry even the most delicate materials with a gentle roll-and-fold blending motion, the Devine Standard Conical Vacuum Dryer insures the safest possible drying and mixing procedure. Devine's conical dryer gives you complete recovery of all processed materials and can be so easily and quickly cleaned that most users find handling time is cut in half.

The Devine Conical Vacuum Dryer is a complete, self-contained unit, available in 2½ to 233 cu. ft. capacities and equipped with condenser, hot-water heating system, pipe, vacuum pump and controls. Smaller units like the above, need only water and power connections, and are shipped completely mounted. Larger installations are assembled under the direct supervision of Devine engineers.

We suggest that you explore the many advantages of vacuum mixing and drying. Devine's experienced engineers would like to show you just how easy it is to cut your production time and costs with the Devine Conical Vacuum Dryer. For further details about vacuum drying and mixing—or for answers to your particular processing problem—write us today.

J. F. DEVINE MFG CO — A UNIT OF COX INDUSTRIES

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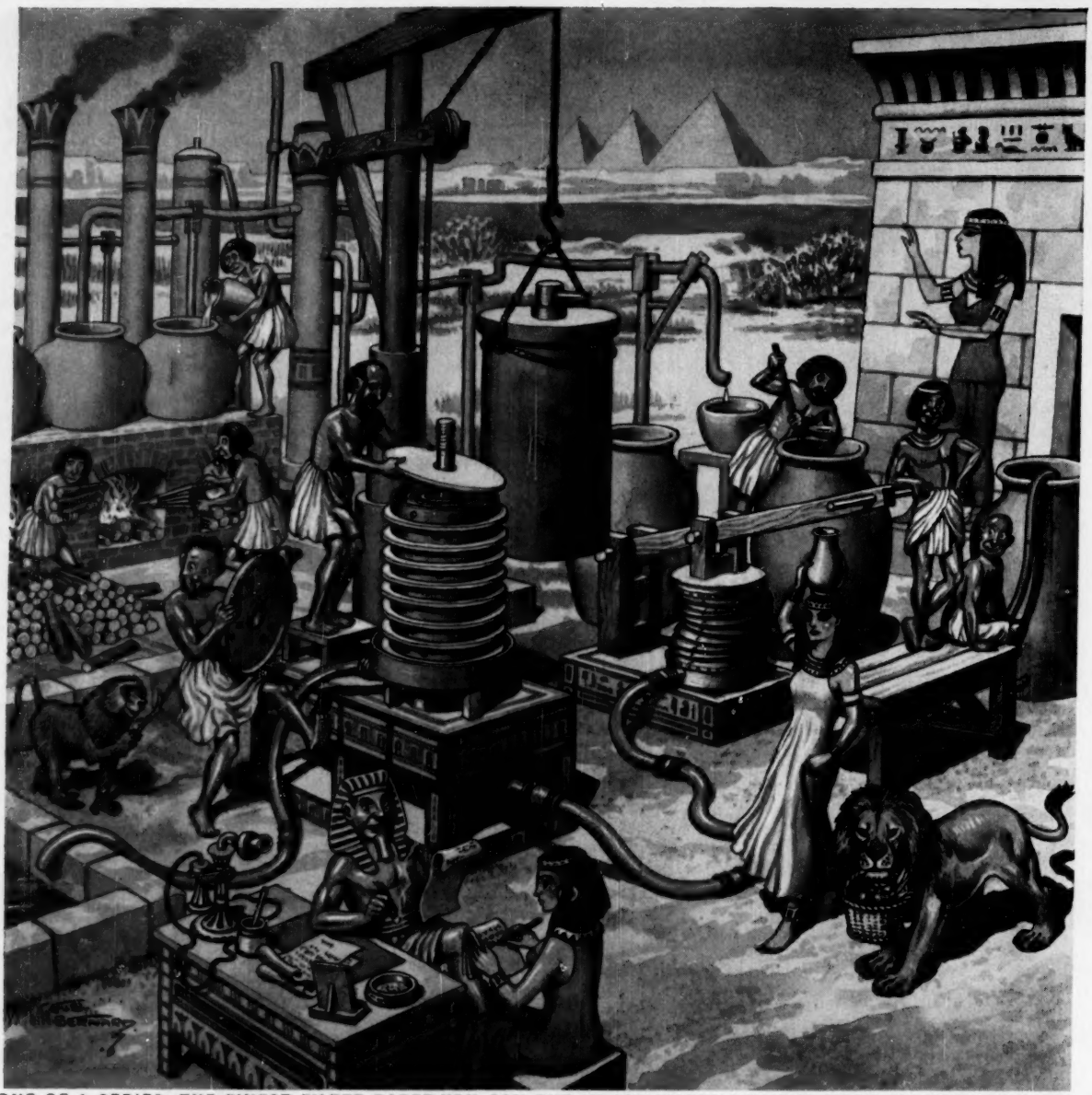

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Nobody comes close to matching E-D's experience in industrial filter papers. We're the only company in America engaged exclusively in the manufacture of filter paper for science and industry. We sell it custom-tailored to your process and your press — cut to your size, folded, punched or made into pads . . . with the right combination of characteristics, including wet strength, flow rate, particle retention, weight, and thickness — to help you achieve maximum filtering efficiency and economy. **And when it comes to technical help and service:** at all times, the experience of E-D engineers, technicians and distributors is available to you . . . to help you in the selection of the right E-D paper for your specific application. **Our 24-page catalog on industrial filter papers gives complete details. Just write for Catalog 357.**

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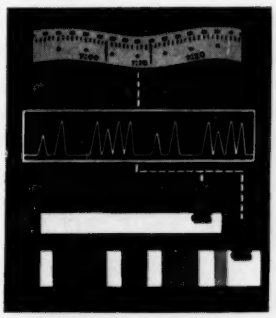
# to achieve greater accuracy and flexibility in process stream analysis . . . MSA brings tape programming to Gas Chromatography

A tape-programmed control unit is the key to improved accuracy and flexibility in MSA's new Gas Chromatograph. It's the first of its kind to be used for this purpose. System consists of a motor-driven transparent film in conjunction with a photoelectric transmitter and receiver to provide any combination of time and sequence required.

The tape is a single continuous loop of standard 16-mm film. It's printed in 1-second graduations. Setting up a program is simple: just mark the tape with a lead pencil at appropriate intervals. Repeatability is to within 1/10 of a second.



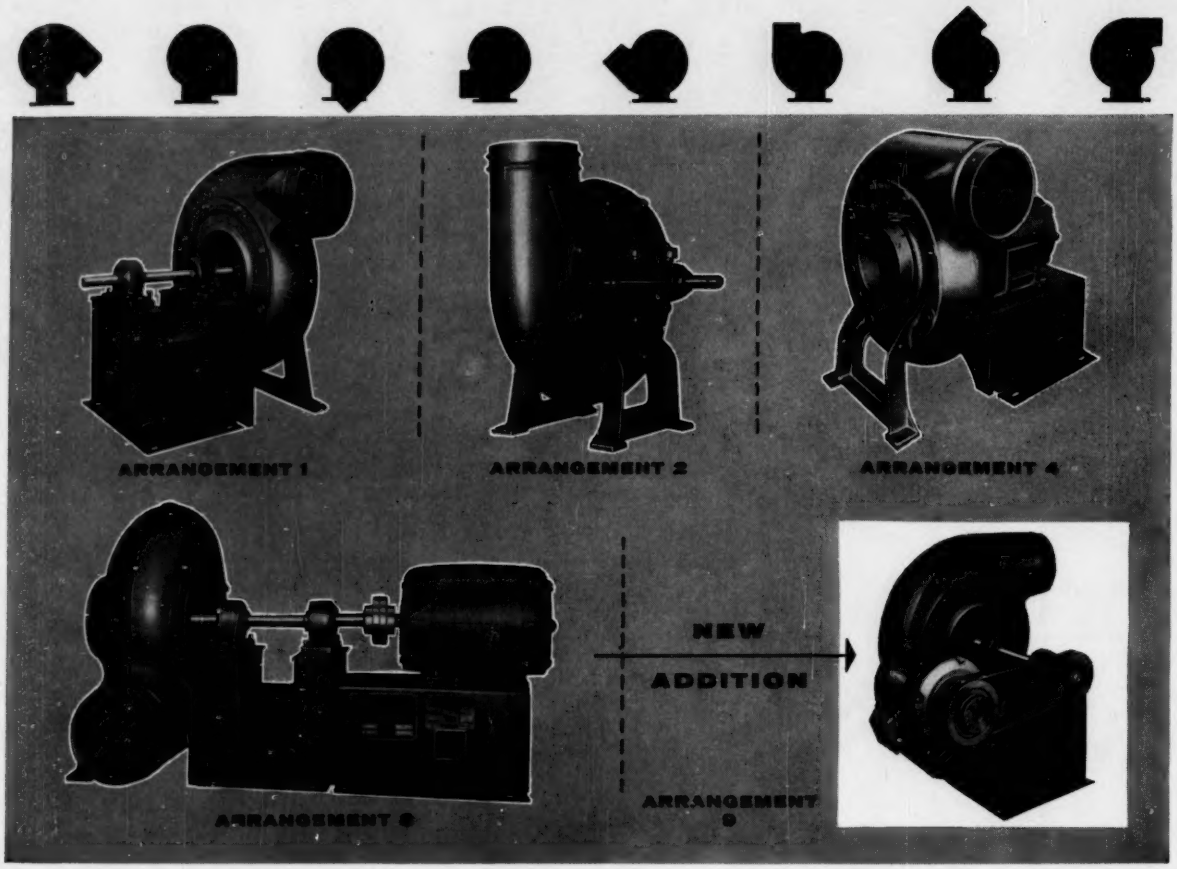
Here are some other features of the new M-S-A® Gas Chromatograph: analyzer temperature is controlled to within .03°F; a three position function switch permits rapid change from bar graph to spectrum presentation or manual operation; and the analyzer unit can accommodate two columns each up to 50 feet in length.

Write for new tell-all bulletin on this new chromatograph.

MSA

*MSA backs up its label with selection, quality, research, experience*

**INSTRUMENT DIVISION**
**Mine Safety Appliances Company**
Pittsburgh 8, Pennsylvania




# Presenting... *the new line of CLARAGE Type CI Exhausters*

Volumes to 3800 CFM, pressures to 18", temperatures to 750°F., six sizes, three wheel types, five arrangements as shown above, adjustable to any of the eight standard air discharge directions.

Result: fan equipment uniquely well suited to nearly every service imaginable. The uncomplicated, heavy construction, featuring cast iron housings and sideplates, makes the Type CI the natural selection for such severe applications as exhausting from grinding, woodworking, and other machines . . . conveying materials ranging from fibers to grains . . . removing smoke and fumes . . . furnishing industrial process air . . . handling chemical and hot gases.

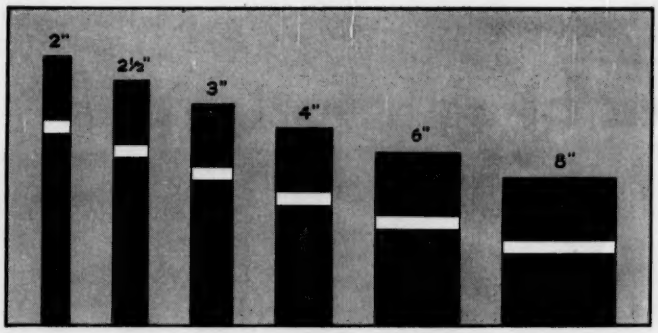
Write for new Catalog 707 containing performance tables, dimensions, and system data. Get acquainted with the advantages you'll enjoy by choosing Clarage Type CI Fans for your next requirements. CLARAGE FAN COMPANY, Kalamazoo, Michigan.

*Dependable equipment for making air your servant*

## CLARAGE FAN COMPANY

*Kalamazoo, Michigan*

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal

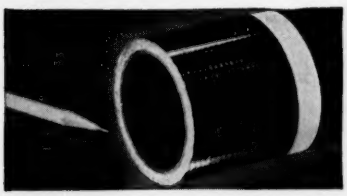



Choose from 6 sizes. Same operating temperature range . . . same operating pressure range . . . same corrosion resistance . . . NEW 6- and 8-inch sizes meet the growing demands of the processing industries.

# Now! A complete size range of Fibercast Epoxy Pipe—including new 6″ and 8″

- *handles a temperature range from −65° to 300° F.*
- *withstands an operating pressure range up to 1200 psi.*
- *pipe sizes from 2″ to 8″*

Only Fibercast, with its unique reinforced epoxy resin construction, can withstand sustained high pressures, high temperatures and extreme corrosive conditions more efficiently than any other pipe. Fibercast's ability to competently handle 320 of 338 corrosive solutions is on record. And now Fibercast, in answer to more of the needs of industry, brings its proven value to larger size flow lines.

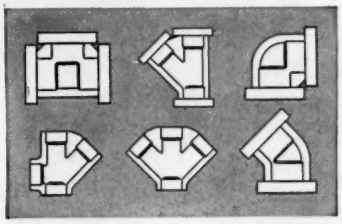


Fibercast Tube and Pipe, ranging in size from 2″ to 8″, is not subject to cold flow or permanent set. It is exceptionally easy to install, readily following ditch contours, saving many costly man-hours where other non-metallic pipes or coated metal pipes simply do not work effectively.

The operating collapse strength of Fibercast is another major factor in its wide-spread use. It has a proven capability of maintaining a collapse load of *twice* the rated collapse!* Moreover, Fibercast is much lighter than steel (less than ¼ its weight) and is correspondingly easier to handle, during both installation and maintenance.

**An additional safety factor is that Fibercast, with its seamless woven glass fiber construction, cannot burst.*

Fibercast Fittings, of course, are also available for the new sizes. They represent the world's most complete stock of standard sizes and types. And, as always, you can have couplings, or even complete piping systems, designed and made to order for your individual requirements.



Get the full story on Fibercast's cost-saving advantages to industry. Learn how it can help *you* solve *your* pipe and tube problems. Mail the coupon today.

**FIBERCAST COMPANY**
**Box 727, Sand Springs, Okla.**

Please send me further information about Fibercast Tube and Pipe. CE-1A

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**FIBERCAST®** COMPANY

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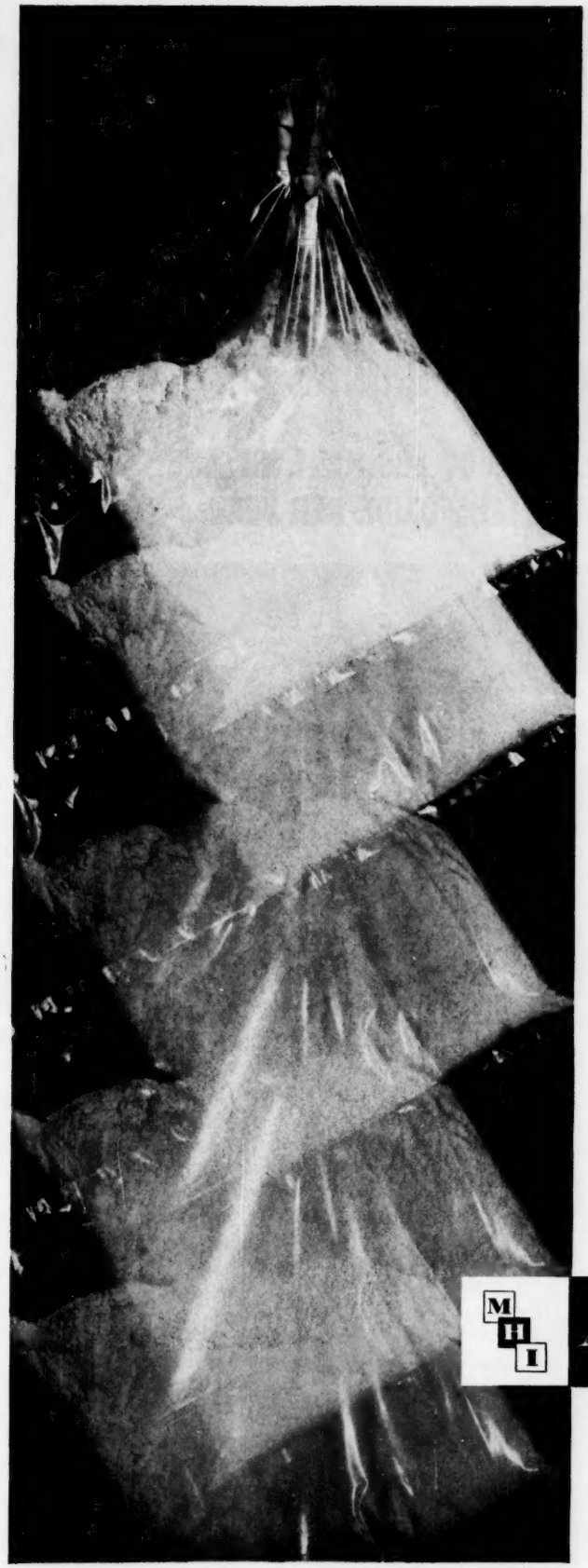


# JUST DROP IT IN! THAT'S HOW EASY IT IS TO USE MHI LITHIUM ALUMINUM HYDRIDE

Anyone can do it! All the productive reactivity of lithium aluminum hydride is safely preserved in ether soluble packaging. Filled with exact pre-determined batch amounts . . . packets are ready to be dropped directly into the reactor. Nothing could be safer, more convenient, or easier to use and store!

But this new packaging technique isn't all. Profitable applications for lithium aluminum hydride have grown, too. A recent development, for example, has shown that by combining other reagents with lithium aluminum hydride, mixed hydride systems are achieved that are exceptionally selective. In some cases reactions take an entirely new course. In others, stereospecific reduction occurs. MHI has a brochure that gives full details.

If your field of interest falls somewhere between steroid chemistry and the development of highly reactive fuels, you need the full story on lithium aluminum hydride. MHI will gladly send it to you. Experienced technical service, too, is available without obligation.

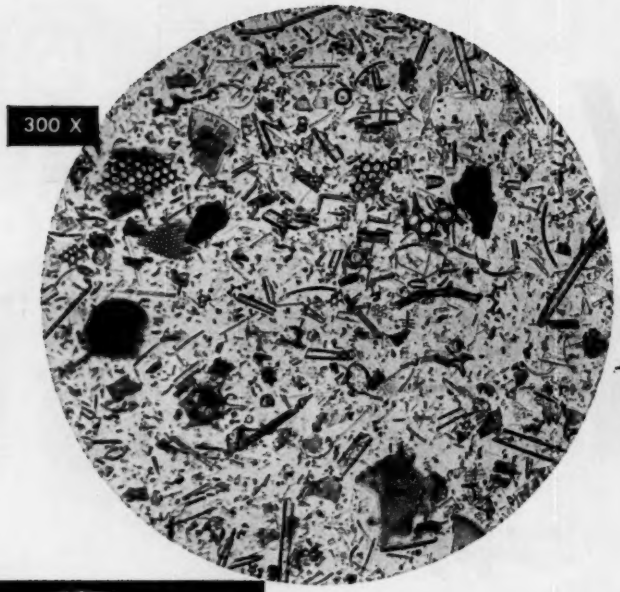
PIONEERS IN HYDRIDE CHEMISTRY

M H I

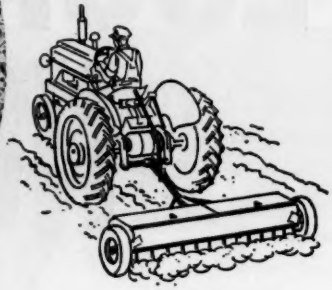
*Metal Hydrides Incorporated*

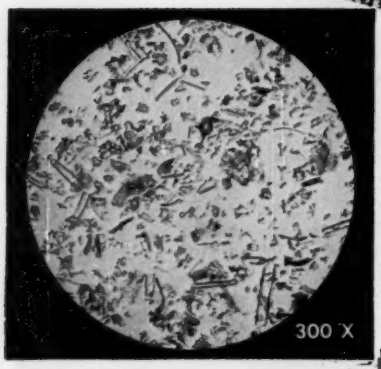
301 CONGRESS STREET, BEVERLY, MASS.

Calcium Hydride • Lithium Aluminum Hydride • Potassium Borohydride • Sodium Aluminum Hydride • Sodium Borohydride • Sodium Hydride Oil Dispersion • Titanium Hydride • Zirconium Hydride.



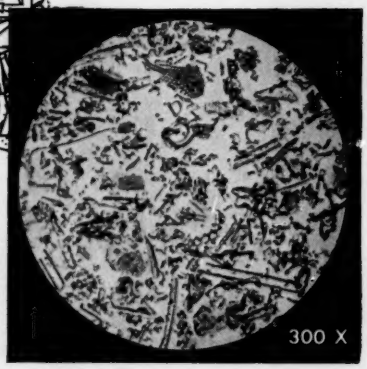

**For fertilizer coating**—Celite 379, a natural milled diatomite, provides the uniform conditioning needed to prevent caking of granular, mixed or prilled fertilizers—maintains good free-flow characteristics even after prolonged storage.

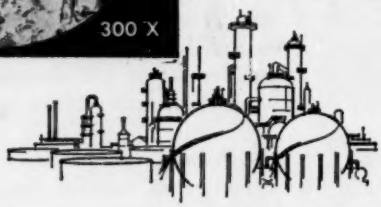





**For catalyst carriers**—Super Floss, finest particle size flux-calcined Celite grade, is used where a non-reactive porous silica support is needed. (Also available: special Celite supports in many preformed shapes for strength, high temperature stability, resistance to abrasion and attrition.)

**As a paint-flatting agent**—Celite 281, air-floated fines of flux-calcined diatomite, provides uniform and efficient flatting at low cost. Contributes to control of low angular sheen, durability, and faster drying.



***In diatomites, Johns-Manville precision processing works for you***

# Celite diatomite absorbs its own weight of liquid . . . yet stays 'dry'

No matter which of the many available grades you choose, you can depend on a given volume of inert Celite* to retain its typical dry-powder characteristics even after absorbing its own weight of liquid.

Actually, Celite can absorb a total of more than twice its own weight. That's because a mass of the fine skeletal particles is approximately 93% air space or voids. Yet, in spite of this very high porosity, Celite is essentially non-hygroscopic.

Other unique properties—extremely high bulk, irregular particle shape and large available surface area—ideally suit Celite to hundreds of mineral filler applications. It is produced with precision from the world's purest commercially available diatomite deposit. It offers a wide choice of grades, each carefully controlled for complete uniformity.

For technical data on specific mineral filler or filtration problems, talk to your nearby Celite engineer. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

*Celite is Johns-Manville's registered trademark for its diatomaceous silica products

**JOHNS-MANVILLE**

JOHNS-MANVILLE JM PRODUCTS

# Wolverine TRUFIN and STEEL ...go together—naturally!

Where corrosion is not a problem—design and operating engineers are finding that they can cash in on money-saving benefits by specifying Wolverine Trufin Type S/T (19 fins per inch) in seamless steel.

Trufin – in steel – possesses all of the inherent advantages of integral finned tube. For example:

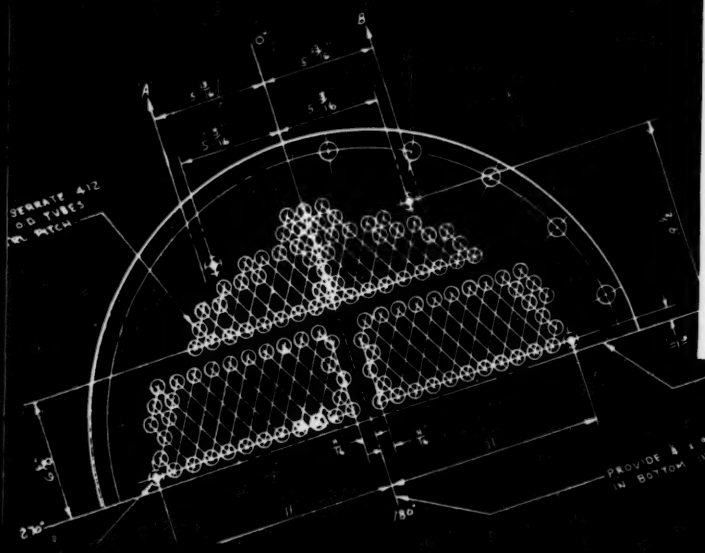
* **In new installations** – Trufin lets you design smaller exchangers without sacrificing capacity. You save on shells, headers, baffles, supports, etc.

* **When retubing**—Trufin's extended surface makes it possible to dramatically increase the capacity of existing exchangers. Trufin Type S/T can be substituted directly for bare tube.

* **Trufin has stamina**—Trufin, because of its integral fins, has the ability to stand up under rigorous operating conditions. Fins are part of the tube wall and are unaffected by the pounding of temperature and pressure changes and vibrations.

Trufin is produced in many types, sizes, and fin spacings – and in steel, copper, copper alloys and aluminum.

***WRITE TODAY FOR MORE INFORMATION.***



# Look to Wolverine for the complete line of finned tube

Trufin Type S/T | Trufin Type W/H | Trufin Type S/T (Duplex) | Trufin Type L/C (Bimetal) | Trufin Type H/R | Trufin Type H/A | Trufin Type I/L

Only Wolverine Tube Division of Calumet & Hecla, Inc. can supply you with such a complete line of integrally finned tube – seven different types designed to bring increased efficiency to a wide variety of heat transfer applications. Each type is available in a complete range of sizes and alloys. Ask your Wolverine salesman for information about how these outstanding tubes can help you.

## WOLVERINE ALSO OFFERS SPECIAL SERVICES AND SPECIAL PRODUCTS

Wolverine's Field Engineering Service is staffed with specialists trained in tubing selection, alloys, metallurgy, equipment design, etc. Also available for consultation are Wolverine's Heat Transfer Specialists who are located throughout the major processing areas. The services of all these men are yours –without obligation.

. . . AND, OF COURSE, WOLVERINE TUBE also manufactures a complete line of copper, copper alloy and aluminum prime surface condenser tube. Ask your Wolverine sales representative about Wolverine's complete line of products and services.

Wolverine Tube is also a prime mill source for palletized U-bend condenser tubes – manufactures them to your "specs" and ships them to you in disposable box-type pallets so that you can feed directly from pallet to condenser.

**WOLVERINE TUBE**
DIVISION OF
**Calumet & Hecla, Inc.**
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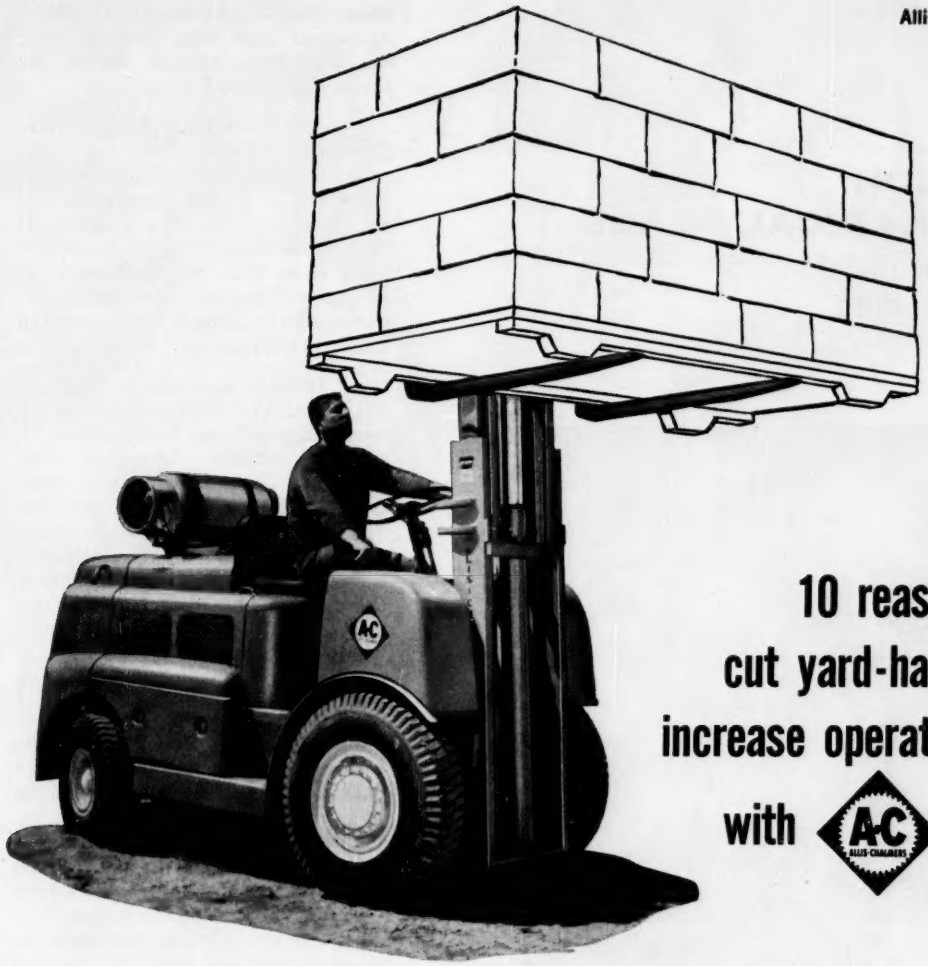
Manufacturers of Quality-Controlled Tubing

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES



Allis-Chalmers FTP60 6,000-lb
pneumatic-tired lift truck

# 10 reasons why you cut yard-handling costs, increase operator efficiency with A-C pneumatics

1. Better performance, indoors or out, with heavy-duty Allis-Chalmers industrial engine.
2. Built for rough yard conditions. Rigid, deep-section steel frame takes stresses, holds parts in alignment.
3. Excellent balance of power and weight design permits outstanding gradability and stability.
4. Faster travel speeds match your job requirements.
5. Choice of standard transmission or two-speed POWER-SHIFT torque converter drive to fit your needs.
6. Operator works in comfort. Cushion seat is adjustable for leg room.
7. Tires last longer than standard tires . . . have much more rubber where wear is greatest.
8. There is extra reserve of electrical power for cold-weather starting, other needs, with 12-volt system.
9. New steel hydraulic lines eliminate chafing and vibration wear.
10. Less downtime because of outstanding ease of servicing and accessibility.

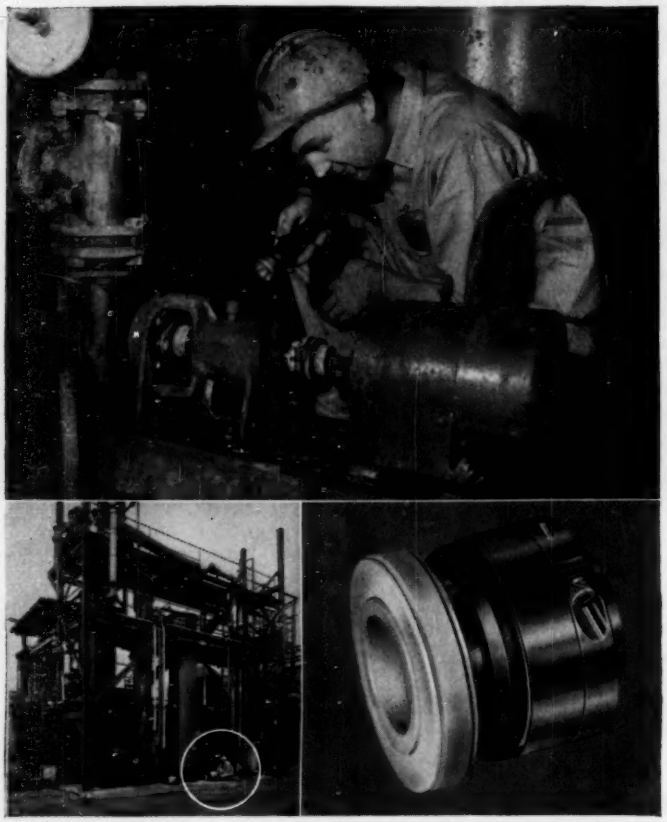
*Let your dealer show you these and many other features of the better-than-ever Allis-Chalmers pneumatic lift trucks.*

*Allis-Chalmers, Milwaukee 1, Wisconsin.*

**ALLIS-CHALMERS**
***POWER* FOR A GROWING WORLD**

BH-151

# TEFLON* MECHANICAL SEALS in Chemical Processing



Garlock CHEMISEAL Mechanical Seals have operated for 27 months without downtime on sulfuric acid pumps (top) on scrubbing towers (lower left) at Kolker Chemical Corp.

**Where others failed, Garlock CHEMISEAL† Mechanical Seals have provided over two years of trouble-free service on pumps handling 98% sulfuric acid.**

Applied by the Kolker Chemical Corporation of Newark, New Jersey, the seals have maintained tight, leak-proof operation of pumps circulating the acid to scrubbing towers at a rate of 20 g.p.m. at an 80 ft. head. Latest reports show that the CHEMISEAL Mechanical Seals have operated around the clock for twenty-seven months without maintenance.

**Ideal for this application,** Garlock CHEMISEAL Mechanical Seals have remained unaffected by conditions of extreme corrosion, damaging abrasives, and temperatures that sometimes reach 100° C at the seal face during process upsets. This performance has helped guarantee uninterrupted processing, has helped protect the product from contamination and has substantially reduced the $200 yearly cost that Kolker previously spent on replacement seals for a single pump.

**Chosen by many leading processors like Kolker,** Garlock CHEMISEAL Mechanical Seals offer a fine combination of benefits. They possess a great immunity to corrosion and contamination, offer long, useful life,and are more economical than many other designs. Good for all mediums including fluids with suspended solids, the seals are pressure balanced and made with a Teflon Bellows to maintain tight seal face contact up to 100 p.s.i. at 167° F or 75 p.s.i. at 212° F.

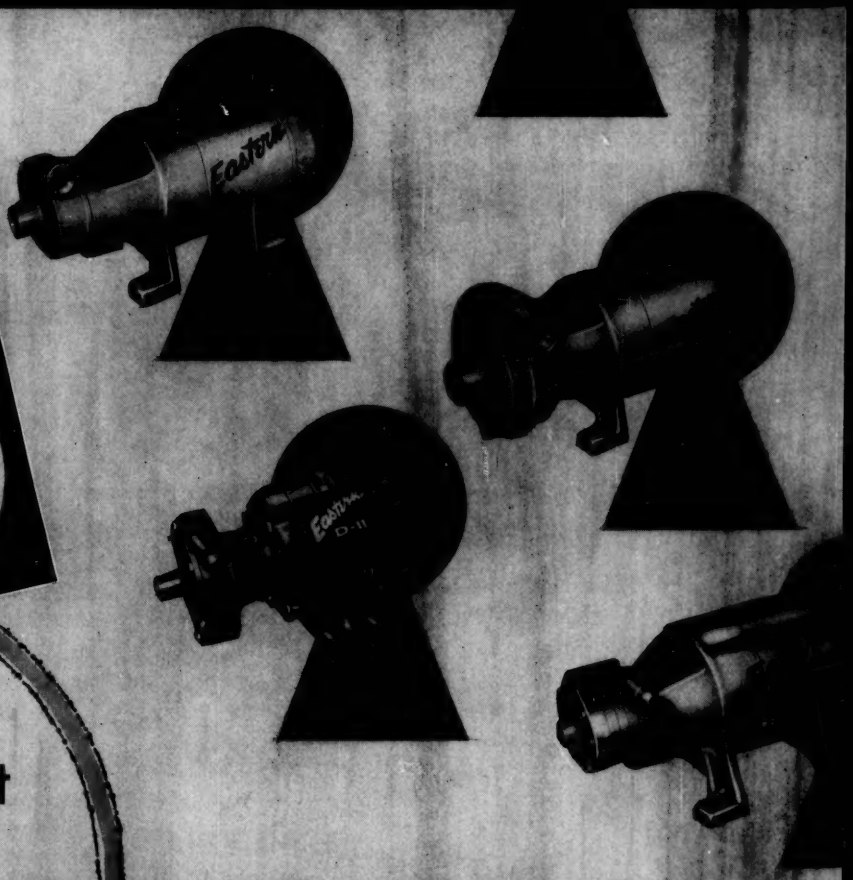
**Find out, as Kolker did, what you gain** by using Garlock CHEMISEAL Mechanical Seals. They are available in standard sizes from $\frac{7}{8}$" to $2\frac{1}{8}$" with a maximum length of $2\frac{5}{16}$". For more details, call your local Garlock representative at the nearest of the 26 Garlock sales offices and warehouses throughout the U. S. and Canada. Or, write for Catalog AD-164, Garlock Inc., Palmyra, N. Y.

# GARLOCK

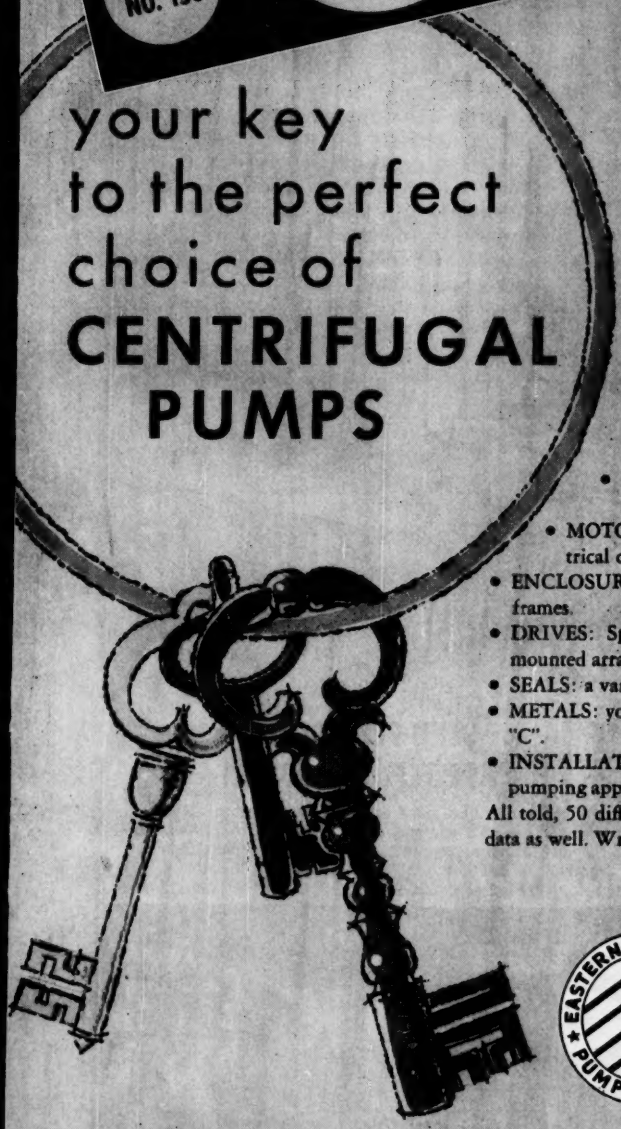
**Canadian Div.:** Garlock of Canada Ltd.
**Plastics Div.:** United States Gasket Company

**Order from the Garlock 2,000 . . .** two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*DuPont Trademark for TFE Fluorocarbon Resin
†Registered Trademark


# your key to the perfect choice of CENTRIFUGAL PUMPS



*A new catalog opens wide the doors to designers of process equipment — tells all you need to know in terms of engineering data, performance charts, seals, metals, mountings!*

If you need centrifugal pumps with these characteristics, this reference book is for you:

- PRESSURES: to 21 psi in single stage pumps; to 70 psi in multi-stage types.
- FLOWS: capacities to 70 gpm in single-stage pumps, to 10 gpm for multi-stage models.
- MOTORS: standard motors for 115/230 volts 60 cycles 1 phase (other electrical characteristics available). Power range from ⅛ to 1½ H.P.
- ENCLOSURES: drip-proof, totally enclosed, and explosion-proof ballbearing frames.
- DRIVES: Space-saving close coupled pumps most rugged and popular. Pedestal mounted arrangement without motor available as alternate for belt or coupling drive.
- SEALS: a variety of rotary seals and stuffing boxes, to fit every application.
- METALS: your option of cast iron, bronze, stainless steel, Monel, Cast Iron, Hastelloy "C".
- INSTALLATIONS: a wide range of transfer, recirculation, feed, boost and filter-pumping applications.

All told, 50 different models are described in full — and you get a wealth of technical data as well. Write for new catalog 130 now!

EASTERN INDUSTRIES ★ PUMP DIVISION ★

## EASTERN INDUSTRIES, INCORPORATED

100 SKIFF STREET, HAMDEN, CONN.

WEST COAST OFFICE 4203 Spencer St., Torrance, Calif.

# ENGINEERING

**NEWS YOU CAN USE ABOUT ENGINE AND COMPRESSOR PERFORMANCE**

## TEFLON* COMPRESSOR RINGS... for special applications

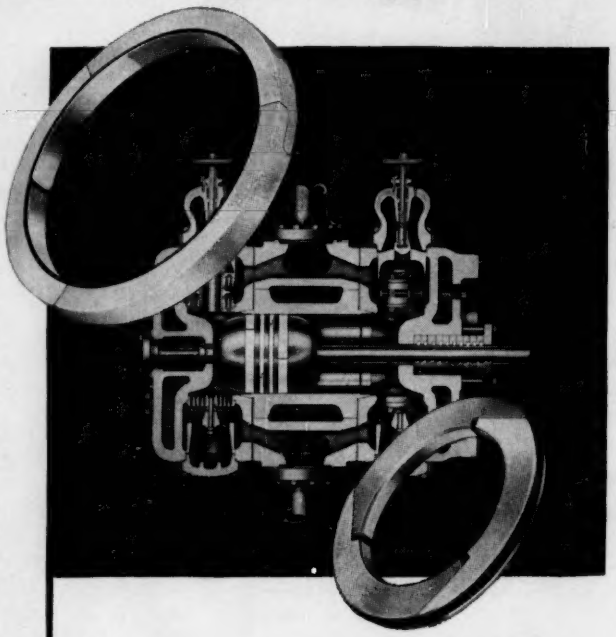
- **TEFLON eliminates or minimizes compressor lubrication**
- **TEFLON is inert to most harmful chemicals and solvents**

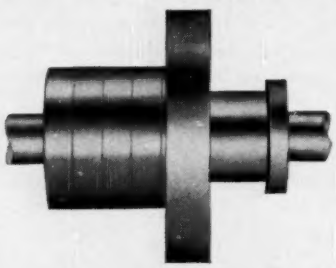
Cook-engineered Teflon packing and piston rings now make it possible to reduce or completely eliminate compressor lubrication. Because of its extremely low coefficient of friction—its toughness and resiliency—Teflon is suitable for both lubricated and non-lubricated ring service.

And just as important, Teflon is completely inert to most chemicals and solvents—thus prevents costly product contamination or other damage which might result with ordinary ring materials.

If your special processing applications demand "borderline" compressor lubrication, you'll want to investigate Cook's Teflon rings. You can get them any size. And they are available in many special Teflon blends, depending on your application. Ask a C. Lee Cook representative to give you the details.

**Teflon is a du Pont product of thermoplastic tetrafluorethylene resin.*





### NEW PACKING DESIGN TAKES HEAT OFF TEFLON RINGS

This unique packing design now being developed by Cook keeps Teflon rings cool! It is a new idea for application where Teflon's qualities are needed, but where normal operating conditions develop too much heat for conventional designs.


### SEND FOR FREE 6-PAGE TEFLON BOOKLET

If you would like more complete information about new Teflon packings and Teflon piston rings for your specific applications, just write: C. Lee Cook Company, 958 South 8th Street, Louisville 3, Kentucky.

**C. LEE COOK COMPANY**

Division of Dover Corporation

*Rings and Packings Since 1888*

# Struthers Wells FIRED HEATERS

The heater above is installed in the refinery of a leading Mid-Continent oil company. Extending to a height of 150 feet, the heater is one of the largest of this type ever built.

Designed for high thermal efficiency, the heater is used on isobutane stripper reboiler service. Dual fuel burners allow the use of a wide range of fuels. Special wind boxes are provided to reduce burner noise level to a low figure.

This heater is typical of the wide range of equipment offered for standard and special requirements, including the highest commercial temperatures. Many special systems have been constructed for unusual requirements. Waste heat boilers and economizers for reclaiming heat from high temperature gases have also been supplied.

*For additional information and address of your local Struthers Wells representative, see Chemical Engineering Catalog, pages 1541 to 1560.*

**STRUTHERS WELLS CORPORATION**
**WARREN, PENNSYLVANIA**
Plants at Warren and Titusville, Pa.

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Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels.

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BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

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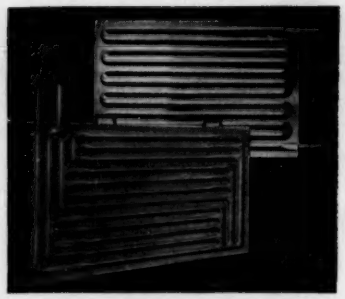
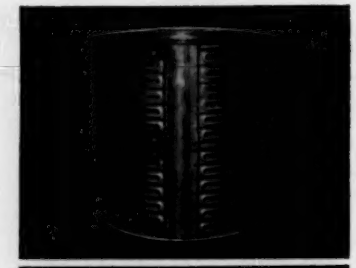
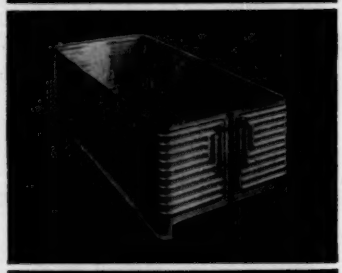
Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening and Backup Rolls

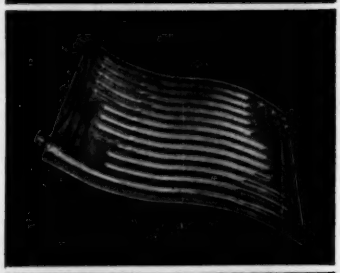


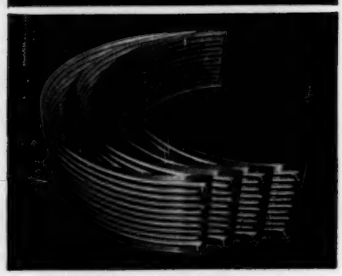
# PLATECOIL®

"STANDARD" STYLES OR SPECIALLY FORMED AND FABRICATED









# =a SOLUTION

## TO DIFFICULT HEAT TRANSFER PROBLEMS

Now you can apply the engineering, installation, operational and maintenance advantages of PLATECOIL to more tank and process heating and cooling problems than ever before. Standard units with exclusive "MULTI-ZONE" pass design for faster heat-up and temperature recovery or serpentine pass arrangement satisfy many requirements. These "standard" styles, available in a wide variety of sizes can be factory-fabricated into banks to fit the application. PLATECOIL can be formed and rolled to specified diameters or even fabricated to form tank walls.

PLATECOIL provides a "packaged" answer to many heat transfer problems, avoiding costly engineering and fabricating of pipe coils. Units are easy to install and maintain—with simple connections, light weight, and streamlined surfaces. High heat transfer capacity permits compact, space-saving units.

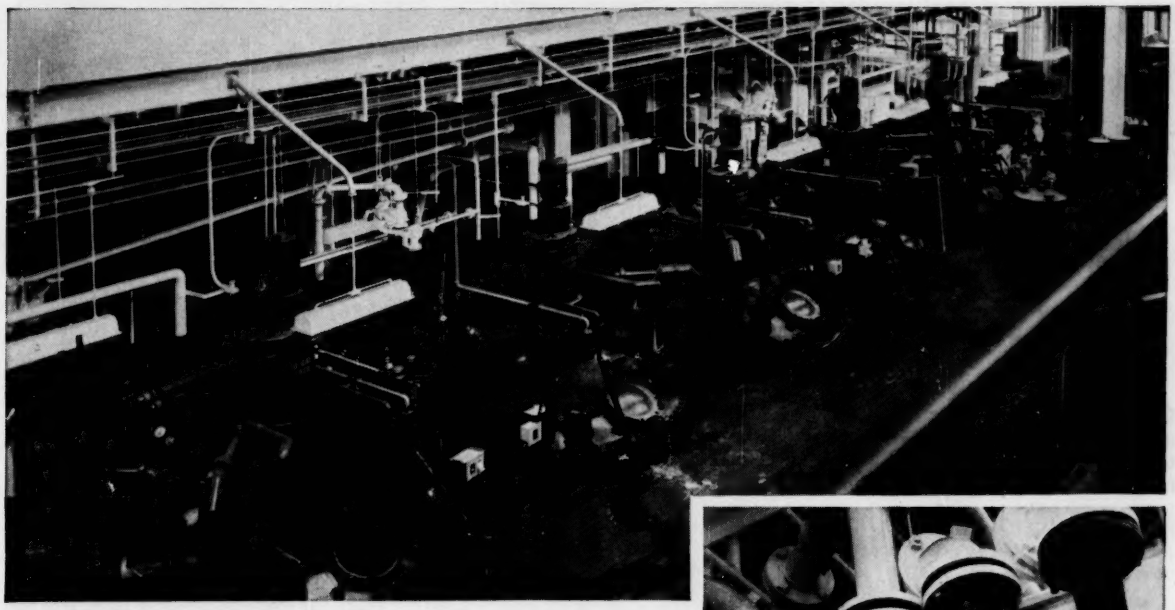
Both "standard" and specially built PLATECOIL are available in mild steel, stainless steel, Inconel, Monel, Ni-O-nel, Hastelloy B, C and F, Nickel and other weldable materials. Operating pressures up to 250 psig. Safety factor—5 to 1. Double embossed or one side flat. Complete engineering data and assistance available.

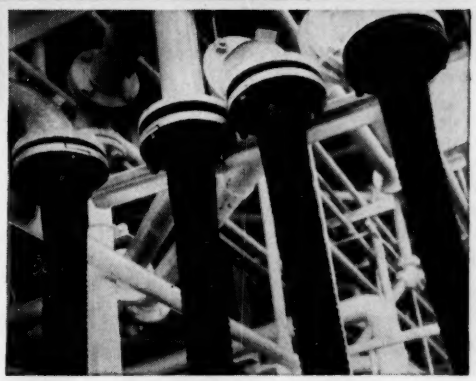
Ask for Bulletin P61.

Tranter Manufacturing, Inc.

LANSING 9, MICHIGAN

PLATECOIL® DIVISION





# R/M RUBBER HOSE Helps Hold Costs *Down* in Modern Chemical Plants

For example, at the new ultra-modern plant of Toms River—Cincinnati Chemical Corporation at Toms River, New Jersey—R/M custom-engineered hose saves manhours and protects vital processes. That's because R/M engineering made certain the *right* hose was made and supplied for each process function. Typical are the lines on the huge Manhattan rubber lined kettles shown above. The lengths of hose at right are specially engineered and equipped with leak-proof Hydro-Lok flanges to overcome process pipe-line problems. Throughout the Toms River plant, R/M hose constructions meet specialized job requirements handling corrosive chemicals and similar process solutions.

You can expect the same "engineering" with the R/M hose you specify for your plant. Easy handling Homoflex is ideal for wash-down operations, or wherever you use air or water hose for general service. For handling chemicals and acids, there's R/M Teflon Lined Hose and Condor Acid Hose available with rubber, neoprene, Butyl or Hypalon tube as required for specific conditions. Condor Flexible Pipe can outlast iron or steel as much as 10 to 1 for highly abrasive or corrosive solutions. R/M Rubber Expansion Joints will eliminate pipeline stresses, misalignment and vibration.

Depend on your R/M representative to suggest the engineered R/M hose construction to help you hold costs down—give you "More Use per Dollar" on every job.

RM 1011

*ENGINEERED RUBBER PRODUCTS ... MORE USE PER DOLLAR*

RM

**RAYBESTOS-MANHATTAN, INC.**

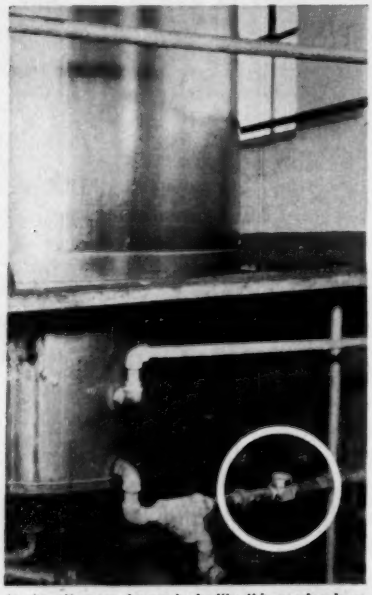
**MANHATTAN RUBBER DIVISION, PASSAIC, NEW JERSEY**

# SARCO TOPICS

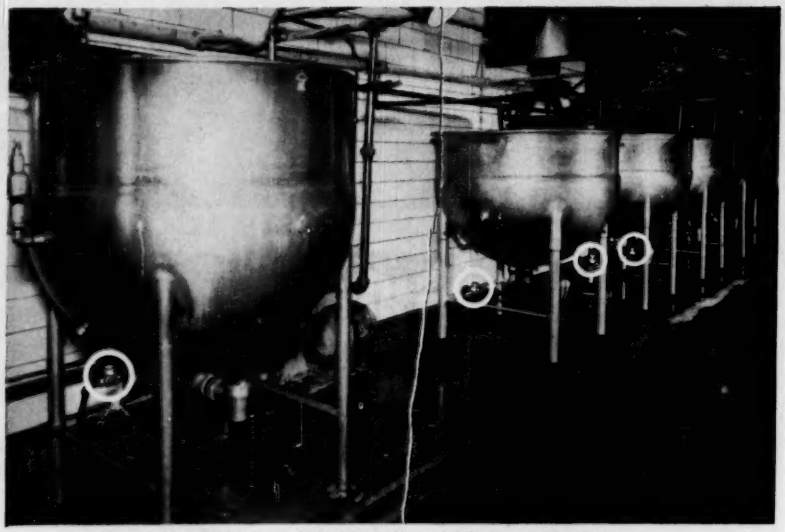
## How to reduce cooking time and trap maintenance in kettles and holding tanks

**College Inn Food Products Corp.** of Chicago faced a problem familiar to many food processors: excessive heat-up time for kettles and holding tanks, and time lost for steam trap maintenance. They found old-fashioned bucket traps at the root of this costly problem.

Specifically, College Inn wanted to shorten both cooking and recovery time in their 150-gallon jacketed kettles... cut heat-up time for both the kettles and their 1000-gallon holding tanks... materially reduce down-time for trap repairs or replacement.



Heat-up time on storage tanks like this one has been reduced approximately 20%. The 1" TD-50 trap on this application replaced a 1½" bucket trap.



With TD-50 traps installed on these kettle rows, down-time for trap maintenance is virtually nil — over years of service.

**These problems were solved** by installation of Sarco Thermo-Dynamic Steam Traps, Type TD-50 to replace bucket traps. On slow cook kettles the ½" size was installed; on fast cook kettles, the ¾" size; 1" traps went on the 1000-gallon storage tanks.

Results were evident at once: Heat-up and cooking time was reduced on all kettles. Where each kettle row had previously required two or three hours per week of shutdown for bucket trap service, maintenance has now dropped to practically zero. Some traps have been in constant service for three years without attention. These results, though noteworthy, are typical. They were achieved because the TD-50 always discharges condensate as rapidly as it is formed; it cannot collect and slow down schedules.

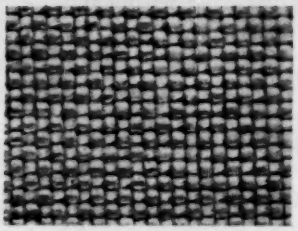
Plant Engineer John Maurisak says: "I'm happy because of freedom from trap maintenance problems, and the cooks are happy because of the fast recovery of the kettles."

**Other food processing problems** will yield to Sarco TD-50's too. Where slugs of condensate and wet steam disturb processing, the TD-50 can be used to control moisture content automatically, easily. Kettle cold-spots caused by a faulty trapping system which does not discharge condensate and air adequately, can be cleared up easily with TD-50's. Other advantages include simplified piping, saved space (because TD-50's are much smaller than conventional traps), easily maintained cleanliness of surroundings.

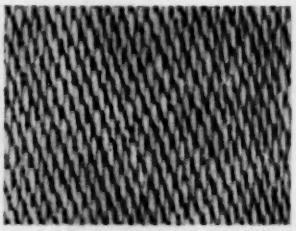
4189

*For information on Sarco Thermo-Dynamic Steam Traps, Type TD-50, contact your Sarco Sales Representative, district office, or distributor, or write.*

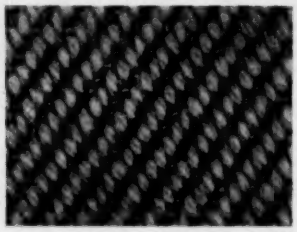
# FILTER FABRIC QUIZ



**1.** This is a plain weave . . . TRUE ☐ FALSE ☐



**2.** This is a twill weave . . . . TRUE ☐ FALSE ☐



**3.** This is a satin weave . . . TRUE ☐ FALSE ☐

1. TRUE. You can always identify a plain weave by its simple "one up and one down" construction. It permits maximum yarn interlacings per square inch and, in a tight weave, affords high impermeability and covering qualities. Used in cottons and synthetics.

2. FALSE. This is a satin weave. With fewer interlacings, spaced widely and regularly, a satin weave has increased porosity, smooth surface and high cover factor. It is valuable in gaseous filtration, such as dust collection. In cotton, commonly known as sateen.

3. FALSE. This is a twill weave—distinguishable by the sharp diagonal line. In equivalent constructions, twills have fewer interlacings than plain weaves—and greater porosity. Filter twills woven of both cotton and synthetic fibers are widely used.

Weave is a very important consideration in the selection of a filter fabric, but many other factors help determine a fabric's performance—fiber, count and finish, for example. That's why you need the assistance of a specialist—like the specialists who distribute Wellington Sears filter fabrics. They're experts in the field—and always ready to lend a hand in helping solve your problems. For their names, and a free copy of our illustrated booklet, "Filter Fabric Facts," write Dept. L-1

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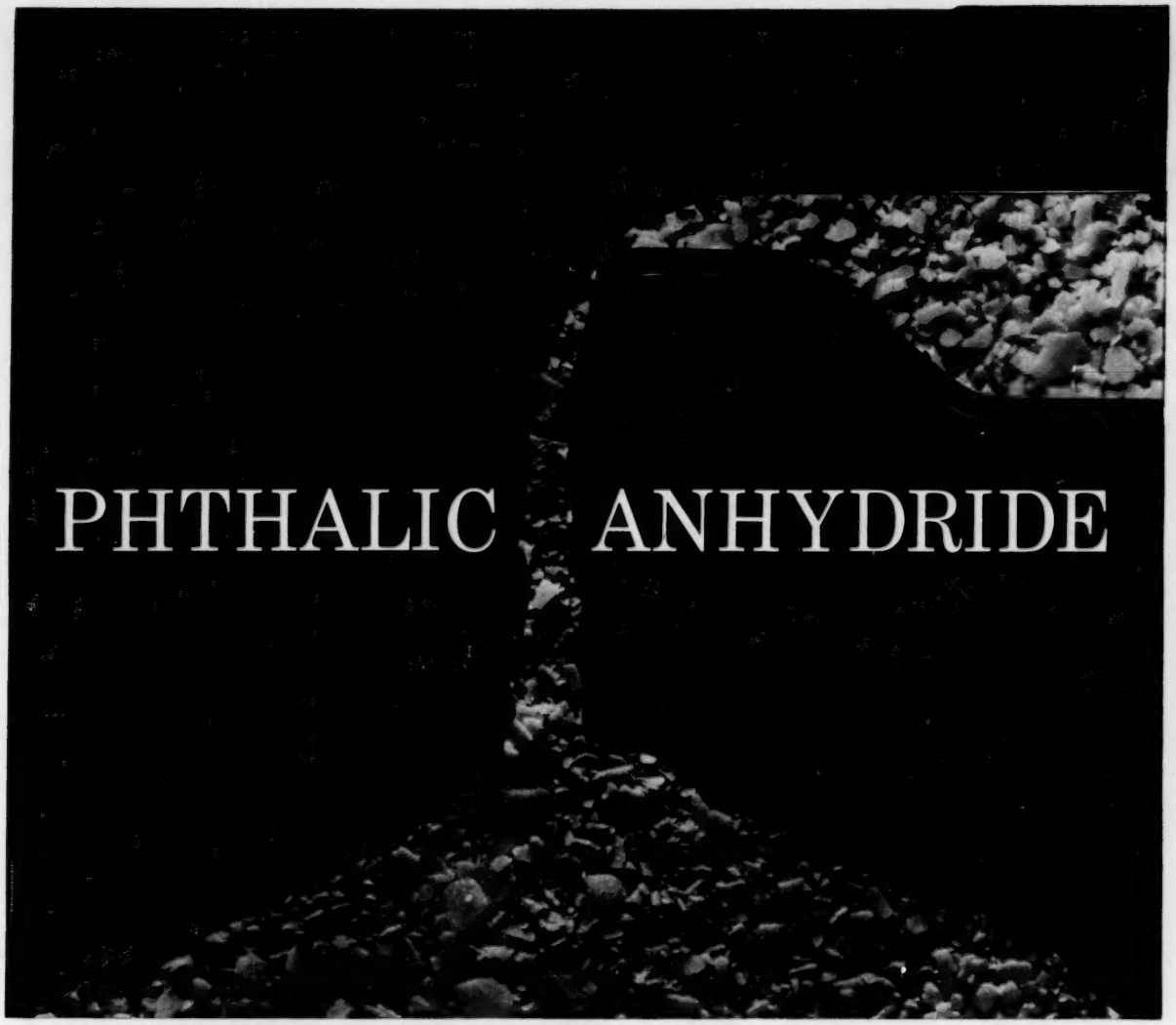


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For 19 years FW has designed and fabricated major equipment for phthalic anhydride plants.

Common to all Foster Wheeler plants is *simplicity* . . . of start-up and operation.

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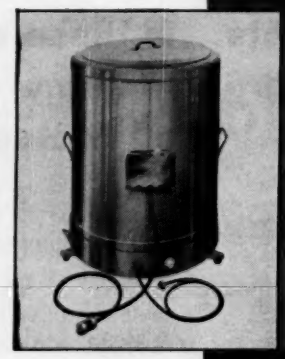
NEW YORK LONDON PARIS ST. CATHARINES, ONT.

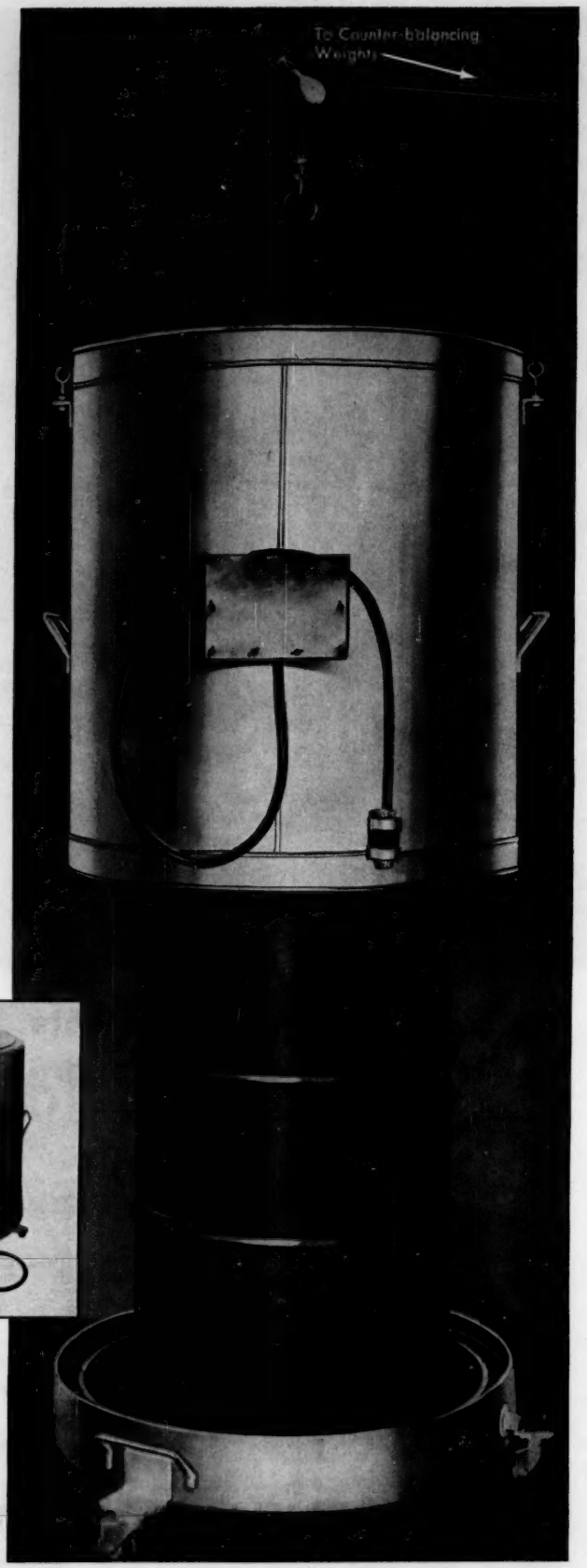
# FOR CONTROLLED HEATING of tars, asphalts, heavy oils, greases, paints, varnishes, pitches, resins, plastics, shortening, gelatinous materials

*Now! . . the Glas-Col Complete Drum Heater is designed for lifting or lowering by pulleys and counter-balancing weights.* One man can easily handle it with one hand! To use, simply place drum on the heater base. Then lower cylindrical part of heater down over the drum. Hook up the two leads. The drum is completely enclosed by the cover, cylindrical and base unit.

Heating elements, embedded in rugged fabric, are close together. This insures uniform input..no local overheating. Accurately controlled temperatures to 550° F can be obtained in base and cylindrical part of the heater by means of separate thermostats. Rugged casters make loaded unit easy to move. The Glas-Col Drum Heater weighs only 95 pounds . . if desired, two men can easily handle it without pulleys and counterweights.



Base part of heater (1800 w, 230 v), **$200.00**.. cylindrical part (6000 w, 230 v), **$340.00** f.o.b., Terre Haute, Indiana. (When ordering, please specify outer diameter of drum chimes. Base or cylindrical unit can be ordered separately.)




**Glas-Col Apparatus Company**

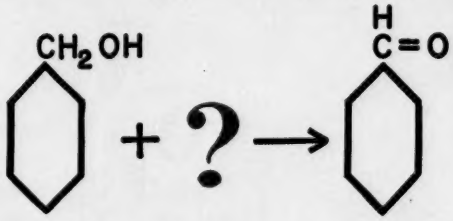
Dept. CR, 711 Hulman Street
Terre Haute, Indiana

**Ask for 4-page descriptive Bulletin DH-100**

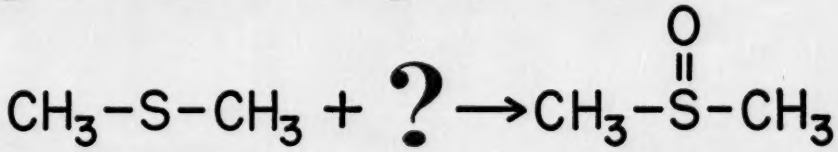
# How would you conduct these difficult oxidation reactions?

***PARTIAL OXIDATION:***

## Aromatic alcohol to aromatic aldehyde

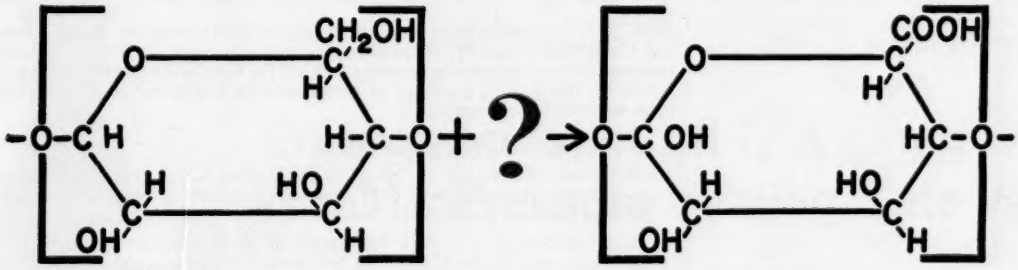



## Organic sulfide to organic sulfoxide




***SELECTIVE OXIDATION:***

## Starch or cellulose--alcohol groups only--to carboxyl groups




Allied Chemical Nitrogen Tetroxide, an abundant source of oxygen, may be the answer to *your* oxidation problems; it carries approximately 70% oxygen. Under mild conditions, half of this oxygen can be utilized; under more vigorous conditions, the total amount is available.

Nitrogen Tetroxide is a truly low cost oxidizer for reactions typical of those indicated above. It can be used in solutions at very low temperatures, such as NO in $N_2O_4$; in concentrated liquid form from −11° to 21° C.; in acids such as sulfuric and nitric; and as a gas in the form of $NO_2$ at elevated temperatures.

With a minimum of $N_2O_4$ content of 99.5% and less than 0.1% moisture, Allied Chemical Nitrogen Tetroxide is supplied in tank cars, one-ton, 150- and 125-lb. cylinders.

For application in your operation, write Allied Chemical.

*For specifications and local offices, see our insert in Chemical Materials Catalog, page 272A and in Chemical Week Buyers Guide, page 27.*

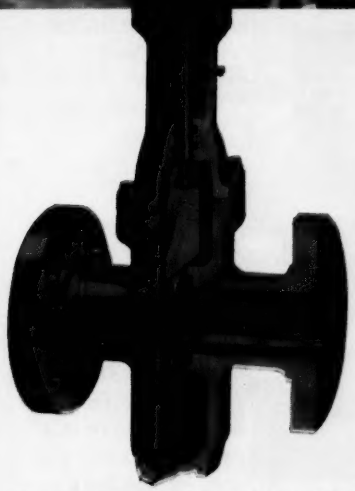
BASIC TO AMERICA'S PROGRESS

Allied Chemical

**NITROGEN DIVISION**
Dept. NT15-5-4, 40 Rector St., New York 6, N. Y.

2819


*4" W-K-M Pressure Sealing Gate Valves serve as emergency shut-off for regulator handling hot P.B.C. at 440 psi, in natural gasoline plant.*



**Floating Seats Make Sealing Easy**

Seats are specially formulated elastomer molded to a hardened steel insert. When the gate closes, line pressure forces the gate against the downstream seat making a tight seal. The upstream seat floats against the gate to maintain an upstream seal.

# Emergency shut-off is a cinch with W-K-M's Pressure Sealing Gate Valve

A unique W-K-M seat design makes line pressure do most of the work — sealing the seats to positive shut-off, upstream and down. But easy operation is only part of the story.

W-K-M's new Pressure Sealing Gate Valve is ruggedly dependable. It automatically compensates for seat wear, automatically relieves excessive body pressure. And on-the-line overhaul is a simple matter.

Wherever you need a smooth-operating valve for pressures to 720 psi and temperatures to 250° F., specify W-K-M's new Pressure Sealing Gate Valve. Sizes 2" through 30" — at leading distributors.

**WRITE FOR CATALOG 1200**

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DIVISION OF ACF INDUSTRIES
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6009

The new Series G CHEMPUMP practically eliminates the only two service points in a pump long known for its low maintenance burden . . . and you'll be pleasantly surprised at its lower price.

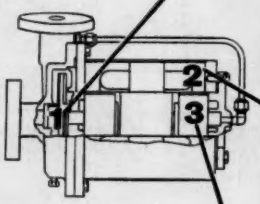
Two new features all but do away with bearing maintenance. A new automatic thrust balance design eliminates axial wear on the bearings by equalizing hydraulic pressures across the rotor and impeller. New front and rear carbon graphite bearings are three times as large, more than tripling radial bearing surface and therefore bearing life.

Motor life is greatly extended because the CHEMPUMP stator cavity is filled with a dielectric oil that increases heat dissipation from the windings. A specially designed relief valve protects the stator cavity against oil pressure buildup.

And you don't have to worry about "new product bugs": The new CHEMPUMP features have been field-proved in more than 100 field installations for over a year.

Series G incorporates many other field-proved design features that have accrued from more than 10 years of experience and leadership by CHEMPUMP—the original canned pump manufacturer.

For a full description of the new Series G CHEMPUMP, write for Bulletin 2050. CHEMPUMP DIVISION, FOSTORIA CORPORATION, Buck and County Line Roads, Huntingdon Valley, Pa.



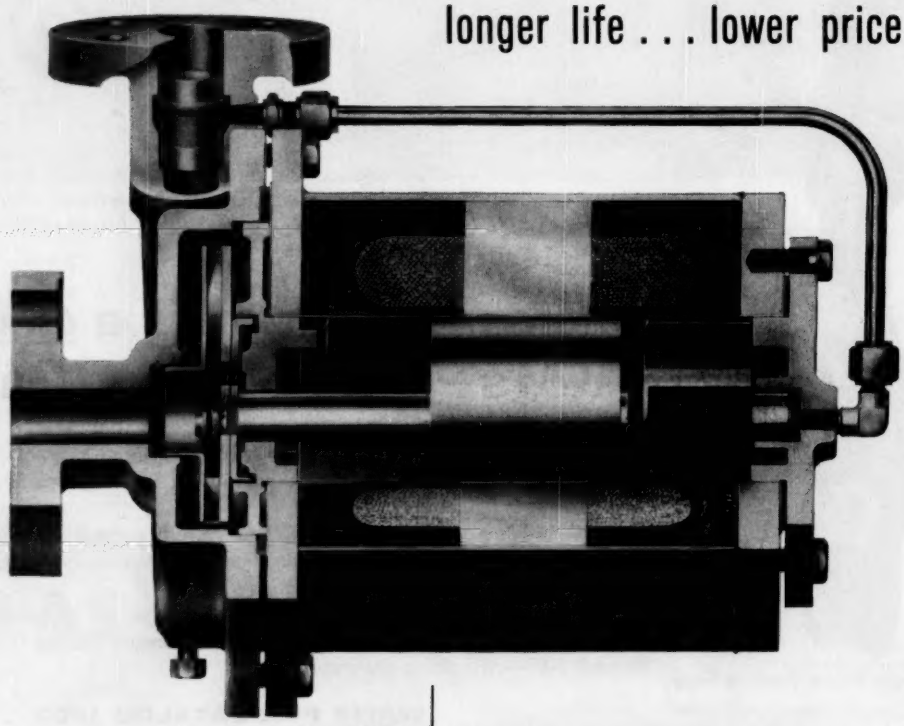

**1** *New Automatic Thrust Balance eliminates axial bearing wear*

**2** *New Oil-Filled Stator Cavity increases life of motor windings*

**3** *New Bearings, three times as large, reduce radial bearing wear*

# NEW LEAKPROOF CHEMPUMP®

## longer life . . . lower price



**CHEMPUMP**

*First in the field . . . process proved*

Top news stories and what they mean to CPI technical decision-makers

# Chementator

## Engineers can collect for pay lost by picket line violence

In what is believed to be a precedent-setting case, a Tacoma, Wash., jury has awarded two American Smelting & Refining Co. employees $3,500 each from a union that barred the men from their jobs by militant picketing during a recent strike.

E. R. Faure, a chemist, and E. P. Titus, chief assayer, won the damages from Tacoma Smelter Local 25 and the International Union of Mine, Mill & Smelter Workers. Judge Robert Cole ruled that the men are entitled to wages lost during the period of the strike. The case is of unusual significance because if the judgment is upheld, it will pave the way for all professional employees to collect damages for work lost during a strike.

Faure and Titus had been issued plant passes and told by management to report for work while the strike was on. They were able to cross the picket line the first day, but the next morning they were met by 50 belligerent pickets, and police finally advised them to return home. They remained away for the duration of the strike.

The union has filed a motion for a new trial. If this fails, it will probably appeal to the state supreme court.

## Tetrahydrophthalic anhydride to shove out big brother phthalic?

Hard hit by the current shortage of phthalic anhydride (due mainly to steel production cutbacks), the plasticizer, alkyd- and polyester-resin industries are taking a good look at Petro-Tex Chemical Corp.'s plans for large-scale production of tetrahydrophthalic anhydride (THPA). Reason: it can be substituted for phthalic anhydride in resins, yielding better initial and retained color, better adhesion. THPA's main drawback now is high cost (39-42¢/lb. THPA vs. 21¢/lb. phthalic).

To slash price down to a level competitive with other commonly used dibasic acids, Petro-Tex plans a "multimillion-lb./yr." THPA plant in Houston. Due on stream in late '61, plant will use the conventional condensation reaction of butadiene with maleic anhydride. These materials should be relatively cheap for Petro-Tex, since it will be the only U. S. company to produce both, when its 30-million-lb./yr. maleic plant comes on stream in Houston later this year.

Right now, the total THPA market is about 2 million lb./yr. The only commercial producer is Allied Chemical, although Stauffer Chemical has development quantities (as byproduct chemical from the company's Perry plant, near Cleveland). Allied has no immediate plans to step up production, although expansion is possible eventually if a definite upsurge in market demand develops.

Petro-Tex began THPA research about six months ago, put a pilot plant on stream in Houston last November.

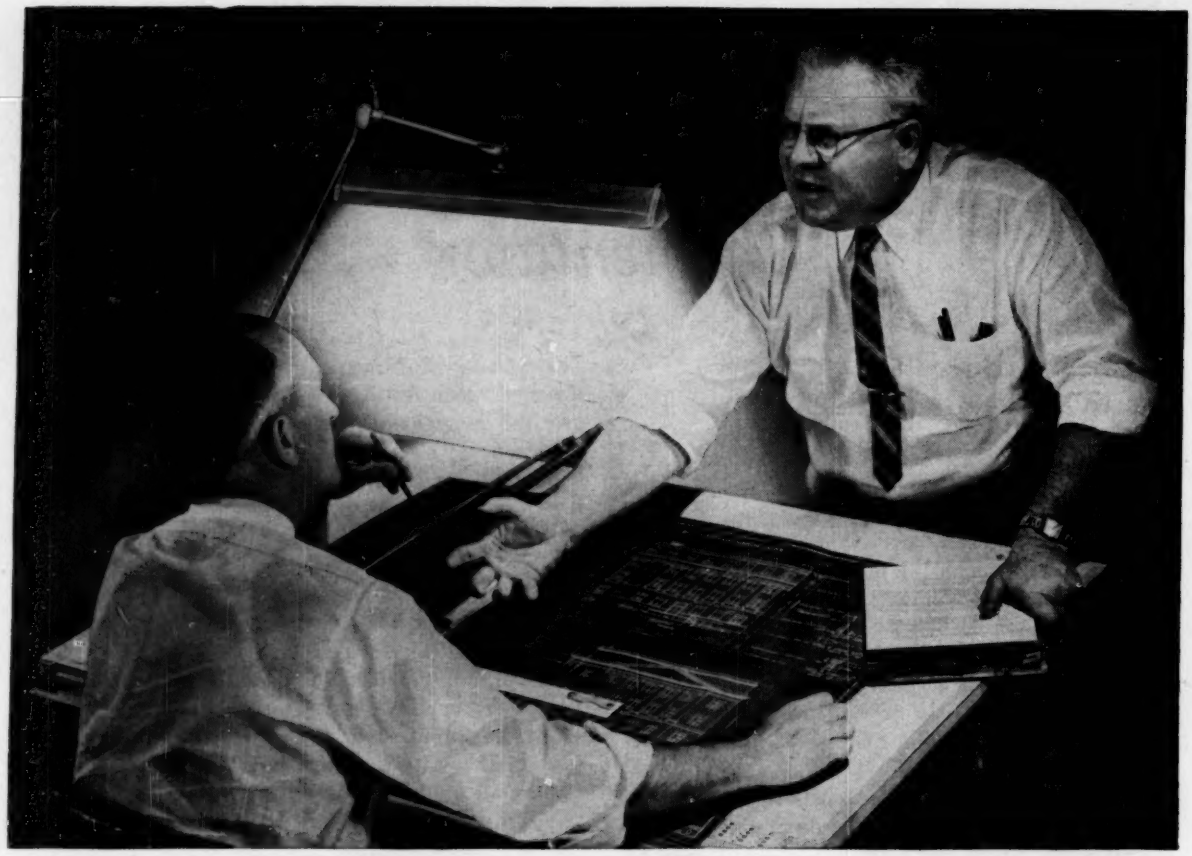
## Two-effect generator on gas cooler saves 35 to 50% of operating cost

By applying a two-effect generator principle to a lithium bromide and water absorption cycle, a new gas absorption cooler is said to produce cooling from a gas flame at an operating saving of 35 to 50% over existing conventional units.

First production unit, slated for use in Texas by the El Paso Natural Gas Co., has a refrigeration capacity of 150 tons, is capable of cooling 40 million cu. ft./day of sour well-head natural gas from 90 to 60 F. Developed by Statham Instruments, Inc., Los Angeles, new unit can also serve as an air conditioner for large structures and even for homes.

Statham claims the following advantages for the cooler: lower fuel requirement, simple construction, low maintenance and quiet operation.

In operation, lithium bromide-water solution, heated by a gas flame, boils in a first-effect generator, giving off water vapor. Concentrated lithium bromide then passes at lower pressure through a coil that serves as a second-effect



## *"Explosion-proof* EXIT *signs!*

## *Where do you expect me to get them ?"*


As you can see, they found the explosion-proof exit sign. It's Crouse-Hinds No. EVA139.

Look in your Crouse-Hinds catalog, of course. There's nearly everything you could want for hazardous areas listed there. Nine different types of explosion-proof telephones... horns, bells, clocks, pilot lights, instrument enclosures, gauge lights. Even X-Ray film illuminators. And, of course, modern designs in all the familiar explosion-proof motor controls, switches, plugs, receptacles, panel boards and lighting fixtures. UL-listed for every Class and Group in Article 500, National Electrical Code.

So, whether you're looking for conventional or out-of-the-ordinary explosion-proof electrical devices, contact Crouse-Hinds. If you design, buy or work with hazardous-area equipment, a Crouse-Hinds catalog should be on your desk. Ask your Crouse-Hinds Representative.

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generator. Coil is heated by condensing vapor from the first effect; because of reduced pressure, the lithium bromide solution boils and more water is released as vapor. The heat thus recovered in the second effect is said to be the basis for the high efficiency and low fuel cost of the cycle.

Vapor from the second-effect generator passes through a water-cooled condenser, combines with condensate from the first effect, and is sprayed over a third coil where it evaporates, cooling whatever product is being handled. The vapor resulting from this evaporation is then absorbed into the concentrated lithium bromide from the second effect, and the now dilute solution is pumped to the first effect to repeat the cycle.

---

***Du Pont and IBM are studying dynamic computer control of a fixed-bed reactor producing acrylonitrile. Slated for operation this fall at Du Pont's Gibbstown, N. J., laboratory, computer will be directly tied to pilot-sized process, without any intermediate controllers. Initial hardware will be an IBM 704, but the final computer is to be developed.***

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## Beryllium continues bullish; more new plants on the way

Despite some skepticism among members of the Materials Advisory Board about the future importance of beryllium (because of its brittleness and toxicity), the beryllium boom continues unabated:

• Mineral Concentrates & Chemical Co. (Denver) reports that within a month it will be producing the first beryllium oxide from domestic ores. Firm says it has perfected a chemical extraction process to produce BeO from low-grade beryl ore mined in Park County, Wyo.

MC&C's mill at Loveland, Colo., and calcining plant at Berthoud, Colo., are designed to turn out 200 lb./day BeO, but can be expanded if demand warrants. Company had originally planned to use an electric calcining furnace at Berthoud, but had to switch to a natural-gas-fired furnace after the electric heating elements failed at high temperature.

• Anaconda has taken options on more than 2,000 acres of beryllium ore land near Ely, Nev. If the deposits prove promising, it could lead to a $10-million integrated mining, concentrating and metal-producing complex.

• Bureau of Mines (Salt Lake City) says that it has developed a flotation process for concentrating beryllium ore found in the Mt. Ely area. Process is said to concentrate the 1% BeO in the ore to 20-22% with about 80% recoveries.

• Beryllium Resources, which has the Van Dornick beryl flotation process (*Chementator*, Oct. 31, p. 41), says its process might be used at African mines to improve both quantity and quality of beryl produced (most beryl is now hand sorted). BR's president Bruce Odlum reports that negotiations involving the Van Dornick process are now in progress in several countries.

• Vitro Corp., one of the early birds at Utah's Topaz Mt. beryllium deposits, says it will have a pilot plant in operation by early spring at Salt Lake City to extract Be values from Topaz ore.

• And Dow Chemical is joining Du Pont and Food Machinery among the chemical companies in the beryllium race. Dow has prospectors scouting for deposits in both the U. S. and Canada.

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## Rising liquid-hydrogen demand generates new contract, new plant

National Aeronautics and Space Administration is strengthening its already strong liquid-hydrogen ties with Linde Co., private industry's sole tonnage producer of the liquefied gas.

To help meet NASA's burgeoning needs for liquid hydrogen, Linde will build a second, much bigger, plant on the West Coast to supplement the 6-ton/day Torrance, Calif., unit that the firm put on stream last summer (*Chem. Eng.*, Oct. 17, 1960, pp. 164-167). And, during plant construction, Linde will serve the government as a liquid-hydrogen shipper, transporting 150,000-500,000 lb./month from the Air Force's "Papa Bear" plant, West Palm Beach, Fla., to NASA locations in the West.

Linde's new plant, stemming from a $31-million NASA contract, will be at Fontana, Calif. Capacity will be 30 tons/day, with 21 tons/day currently slated to go to NASA. Excess capacity

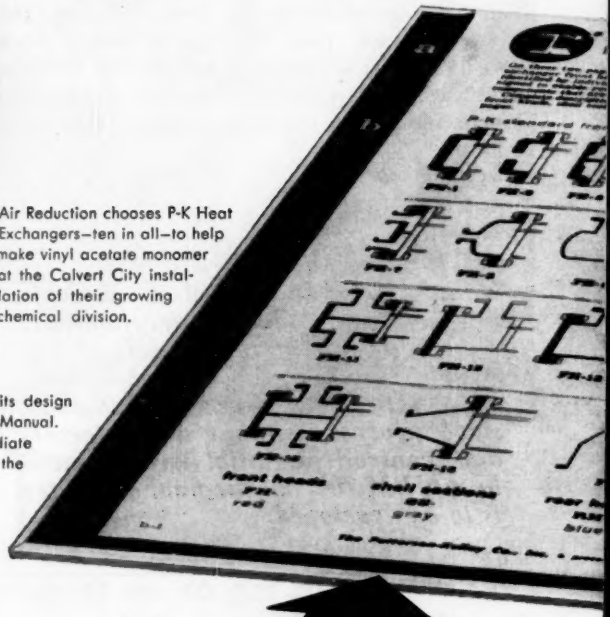
*(Continued on page 74)*

# NEW P-K HEAT EXCHANGER MANUAL SIMPLIFIES SELECTING COMPONENTS FOR INSTALLATIONS LIKE THIS

The P-K HEAT EXCHANGER Manual is a new 108-page work book that makes selection of a heat exchanger far easier than ever before. It enables you and your engineering staff to save time, effort and duplication of work in developing a design that will meet all your performance conditions.

This new work book standardizes terminology. It illustrates and describes components commonly used in processing. It groups interchangeable front heads, shell sections and rear heads. In much the same way, it groups standard gasket joints, tube pass partitions and shell baffles, thus greatly sim-

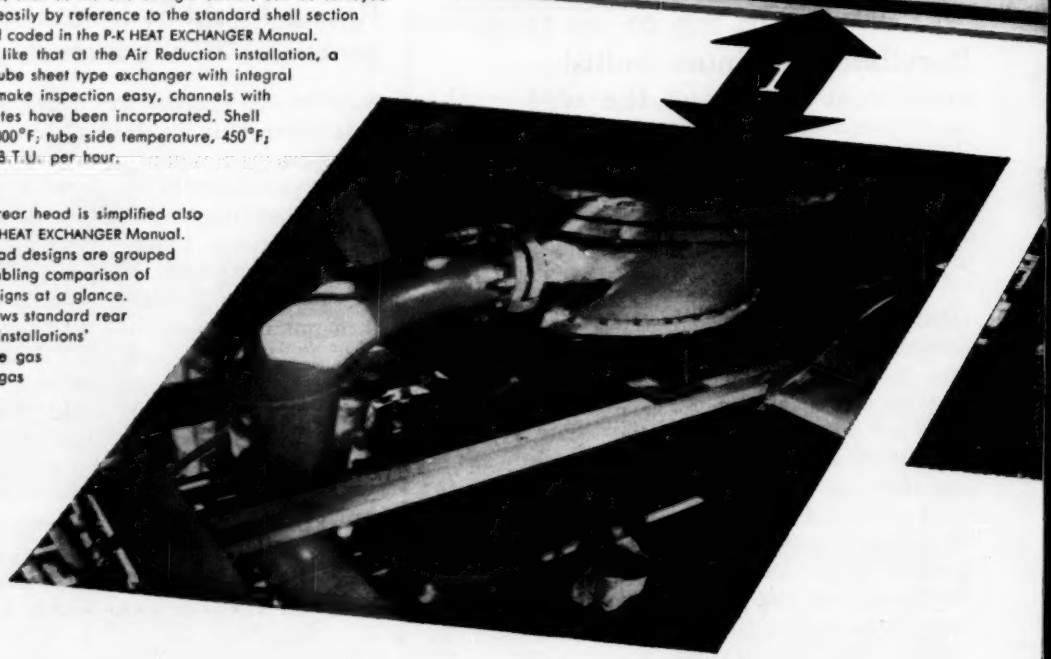
Air Reduction chooses P-K Heat Exchangers—ten in all—to help make vinyl acetate monomer at the Calvert City installation of their growing chemical division.



❶ Which type front head for your heat exchanger? You can "pinpoint" its design more quickly by reference to the head coding index in the new P-K HEAT EXCHANGER Manual. In the Air Reduction installation four P-K exchangers of the type at the immediate right cool crude product gas in the tube side by means of water flow through the shell side. Tube temperature is 300°F; shell temperature 150°F; capacity, 581,000 B.T.U. per hour.

❷ Shell sections, such as the one at right center, can be surveyed and specified more easily by reference to the standard shell section designs grouped and coded in the P-K HEAT EXCHANGER Manual. There are four units like that at the Air Reduction installation, a straight tube, fixed tube sheet type exchanger with integral expansion joint. To make inspection easy, channels with removable cover plates have been incorporated. Shell side temperature is 300°F; tube side temperature, 450°F; capacity is 580,000 B.T.U. per hour.

❸ Selection of rear head is simplified also when you use the P-K HEAT EXCHANGER Manual. Twenty-eight rear head designs are grouped and coded here, enabling comparison of the most popular designs at a glance. Photo at far right shows standard rear head on one of the installations' two refrigerated type gas cooler and liquid-to-gas heat exchangers.



plifying the underlying details of design.

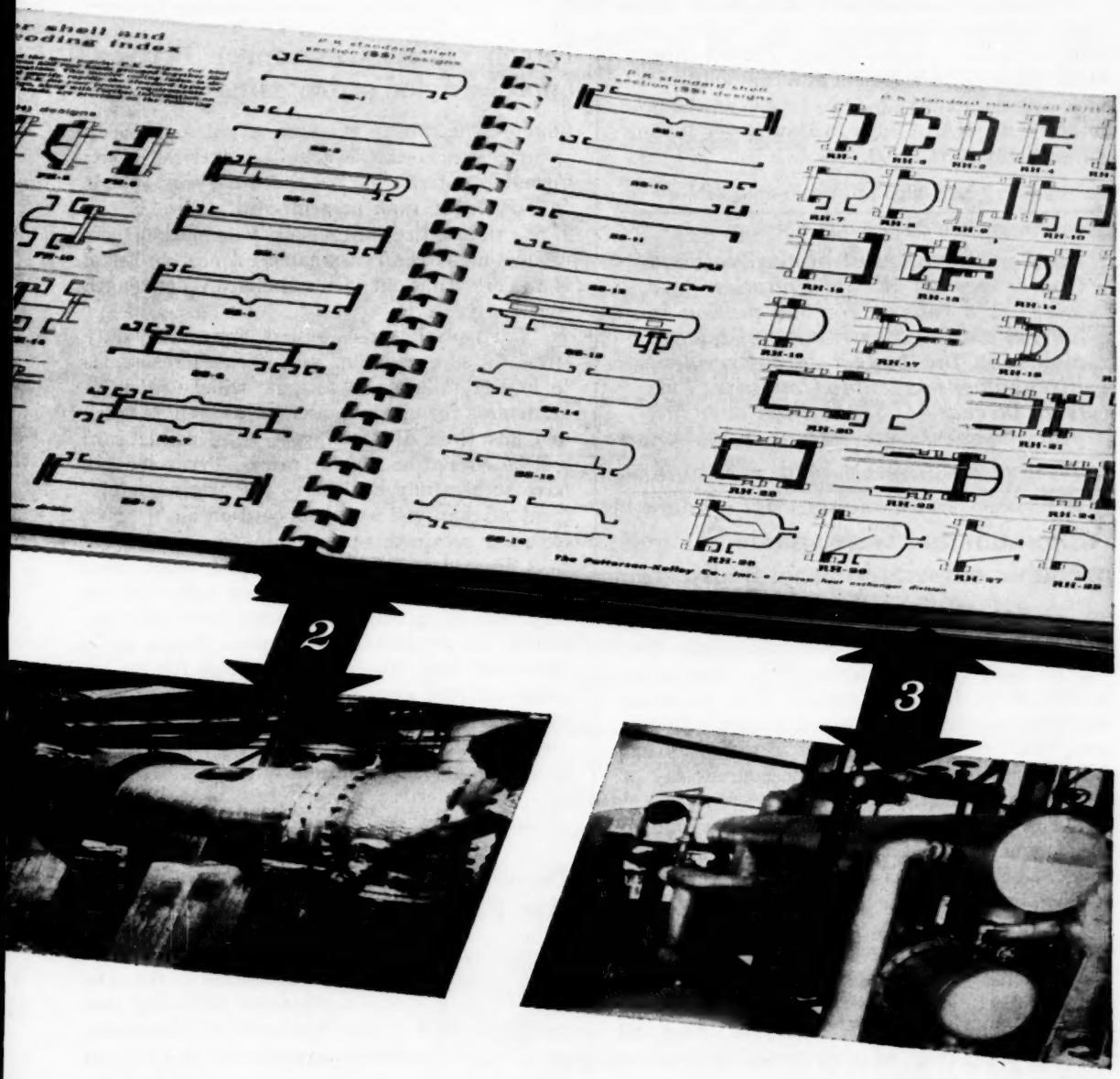
In other sections of the P-K HEAT EXCHANGER Manual you find an outline of the economic and performance advantages of principal designs, a review of the fundamentals of heat transfer, and a number of basic tables and formulas, along with a comprehensive design check list and other features.

As significant developments occur, the P-K HEAT EXCHANGER Manual will be supplemented and the new material sent to registered holders.

Available copies of this useful new manual are limited in number, and therefore are reserved primarily for those in the process industries who can best apply the information. If you design or specify heat exchangers, you are invited to write to us on your company letterhead, outlining briefly the areas of your interest. A few copies are available to students and non-technical personnel at a nominal charge. The Patterson-Kelley Co., Inc., 990 Burson Street, East Stroudsburg, Pa.

**Patterson Kelley**

Heat Exchanger Division



may find a modest outlet in private industry but is mainly intended to satisfy increased government needs during the lifetime of the contract. Construction is set to start this summer, to be completed by June 1, '62.

Company says the facility will use basically the same cycle as its Torrance plant. One difference is in feedstocks—Torrance treats a hydrogen-methane stream from nearby olefins operations, whereas the raw material at Fontana will be coke-oven gas.

Among NASA projects pointing to high liquid-hydrogen demand are the Saturn and Centaur rocket programs and Project Rover, which concerns development of a fully integrated nuclear rocket using liquid hydrogen as the propulsion fluid. NASA says Project Rover testing will probably start in '63.

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***First concrete result of the National Conference on Water Pollution (see p. 78) is a request for $50 million in federal aid for construction of sewage plants, in the budget that President Eisenhower has sent to Congress. This is an increase of $30 million over last year's request.***

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## Aluminum and water named probable culprits in reactor disaster

The explosion in the atomic reactor at the National Reactor Testing Station, Idaho Falls, Ida., was probably caused by a reaction of overheated aluminum in the fuel elements with the water moderator-coolant. This would generate hydrogen, which could cause a blast of the type that killed three operators, informed sources say of the Jan. 3 accident.

The Atomic Energy Commission is withholding comment until a full investigation has been made. But indications are that the reactor was not on line when the explosion occurred. The three men killed were inside the containment shell; no one was in the control room.

Reactor, called Stationary Low Power Reactor No. 1 (formerly Argonne Low Power Reactor), had a previous history of creep and growth trouble in the aluminum-clad fuel elements. Too, excessive corrosion of the boron poison strips, welded to the elements, has raised the possibility that reactivity in the core may have risen to a point beyond the control rods' ability to contain the reaction.

Some observers postulate that the reactor, during some maintenance procedure, may have suddenly gone critical. The excessive heat generated then caused the aluminum-water reaction (which can be explosively violent), releasing the hydrogen that could have caused the fatal blast.

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## Rayon vs. nylon: stronger Tyrex opposes nylon's tire gains

Counterattacking in the face of gains rolled up by nylon tire cord, Cleveland's Industrial Rayon Corp. has entered the fray with a Tyrex that is 10% stronger than present cord. (Firm is one of five viscose tire-cord makers who market their product under the Tyrex name.) American Enka, New York, came out with a similar high-strength cord last year.

Particularly well suited for heavy-duty tires, the new cord has an increased resistance to impact failure and fatigue, will be made in all deniers for use in passenger as well as truck and bus tires. IRC's biggest sales point: cord will be offered at regular prices. Tyrex makers have successfully held on to the original equipment market, will see their cord on all '61 cars, expect to retain this position in '62.

Since viscose prices are probably much closer to the irreducible minimum than nylon (*Chem. Eng.*, Jan. 9, p. 86), Tyrex's ultimate fate may depend on product improvement. Hence IRC's statement that "there is sound basis for the expectation that even more improved Tyrex cord products will be developed in the near future," may indicate that the present development is just a preliminary skirmish in a battle yet to come.

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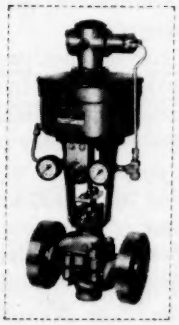
## New tricks for old chemical; Air Force adopts fuel de-icer

A well-known chemical—Union Carbide's Cellosolve—has taken on new importance as the principal ingredient in a new jet-fuel anti-icing compound adopted by the Strategic Air Command. As an indication of the importance of this development, unofficial Air Force opinion is that the flameout that led to the U-2 "incident" would

# THANK YOU, COMPETITION!



Thank you control valve manufacturers. We see by your ads in the trade press and your exhibits at shows, that you are now offering split-body valves with cylinder actuators.

As most of you know, we have been manufacturing and marketing our Series LB split-body, cylinder-actuated valve for ten years. When we first started making the Series LB control valve—a radical departure from the then conventional double-seated valve with spring and diaphragm actuator—we did it because we sincerely believed it was the best way to control process fluids.

Those of us who pioneered the split-body, cylinder-actuated valve invested considerable time, money and effort in extolling its many features. As the years went by and user acceptance increased, we became stronger in our belief. However, there were many times during those years when we would have welcomed confirmation from you in the form of competitive products. Now, your announced entry into this field is, to us, a gratifying endorsement of the concept we have spent so much of our energies in developing. The added impetus that your collective advertising and sales efforts will give to publicize the benefits of the split-body, cylinder-actuated valve will contribute materially to its universal acceptance.

Although we know we have a good product backed by a decade of design and manufacturing experience, we do not intend to rest on our laurels. We will continue to offer industry the very best control valve we can make. And you will strive to outdo us. Your customers—and ours—and our industry—can only benefit from this healthy competition. Again, we thank you for following this lead in control valve technology.

CONOFLOW SUBSIDIARY WALWORTH

**CONOFLOW CORPORATION**

*FOREMOST IN FINAL CONTROL ELEMENTS*

**2100 ARCH STREET, PHILADELPHIA 3, PA.**

never have occurred if the plane had possessed the new de-icer, reports *Aviation Week*, a McGraw-Hill publication.

And although the de-icer has been flight-tested mainly on the B-52 and KC-135, indications are that it will be effective in the Convair B-58 and F-106, as well as the high-flying B-70 now in the works.

Designated PFA 55MB, the de-icer was developed for the Air Force by Phillips Petroleum. The fuel additive consists of 90% methyl Cellosolve (ethylene glycol monoethyl ether) and 10% glycerine. The glycerine is added to make the material compatible with the buna-N lining of fuel tanks.

Icing problem in jet aircraft occurs when water, dissolved in the fuel, separates at low temperatures, and the resulting ice clogs the fuel lines. The de-icer, dissolved in the fuel, separates with the water, lowering the freezing point almost to the freezing point of the fuel itself. The new fuel additive will also probably help eliminate weight-consuming fuel-line heaters developed to combat icing.

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***Contract for the 80-million-lb./yr. acetylene plant for Monochem (joint venture of U. S. Rubber and Borden Chemical) has gone to Chemical Construction Corp. The plant near Baton Rouge, La., will use the BASF partial oxidation process. Partial oxidation was also picked by Diamond Alkali for its new acetylene plant at Deer Park, Tex. Its choice: the Montecatini process.***

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## First private helium plant ready; will be outside government program

What may be the first of several privately owned helium plants has been announced by Kerr-McGee Oil Industries. To be built in Apache County, Ariz., plant will be able to extract 73 million cu. ft./yr. of 99.995% helium.

Plant will cater to commercial customers on the West Coast; there are no known plans to sell to the government. The Dept. of the Interior has been trying to encourage private companies to build extraction plants to produce crude helium, then sell it to the government for final purification (*Chem. Eng.*, Oct. 31, p. 48). But Kerr-McGee feels there are enough commercial outlets to justify a strictly private program.

Main industrial uses for helium: welding, degassing molten metals, leak detection in equipment. Total commercial demand is estimated at only 40 million cu. ft./yr., so any further private ventures may be made in cooperation with the government, which uses many times that amount.

Engineering and design of the new Pinta Field plant will be handled by Air Products, which supplied the low-temperature equipment for the government's Keyes, Okla., plant (*Chem. Eng.*, July 25, 1960, pp. 96-99). Plant will process a nitrogen-helium gas containing 8% He. This is an unusually rich concentration of helium; the Keyes plant has 2% He in its feed and this has been considered rich.

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## Million-dollar question: what feed for new ethylene complex?

Now that Monsanto has confirmed trade reports about its activity at Alvin, Tex., industry men are wondering how the raw material and process picture will shape up for the chemical complex.

These are the facts Monsanto has revealed to date: plant, to be located on Chocolate Bayou, will make 500 million lb./yr. ethylene, 42 million gal./yr. benzene, 50 million lb./yr. naphthalene, 50 million lb./yr. phenol, plus propylene, cumene, acetone, ethylbenzene and "other hydrocarbons." Plant will come on stream in '62; estimated cost is put at $80-100 million.

New plant will require 7-10 million bbl./yr. of hydrocarbon feedstocks, will be linked by three pipelines with Monsanto's Texas City installation, 25 mi. away. Presumably, some of the raw materials could come via pipeline from the Texas City oil refineries.

Monsanto is now said to be shopping around for naphtha feedstocks for the ethylene unit. With the depressed gasoline market, it should be able to get a favorable price. Some of the benzene requirements can probably be met by using the Udex process to extract aromatics from the cracked ethylene stream. But the firm may have to go to hydrodealkylation to make additional benezene, as it probably will do to furnish the required naphthalene.

The plant is located near a big salt dome, which probably will be used for ethylene storage.

*For more Industry news . . . 78*

## Allied Chemical announces 50% boost in HF capacity at Nitro, W. Va. plant

NITRO, W. VA., March, 1960—Allied Chemical's General Chemical Division announced today that it has expanded by more than 50% the productive capacity of its anhydrous hydrofluoric acid plant at Nitro, West Virginia. This is one of several developments which strengthen Allied Chemical's position in fluorine chemicals. The Company has also recently acquired more than one million tons of additional fluorspar reserves.

## B&A opens new facilities for Electronic Chemicals at Los Angeles

LOS ANGELES, June, 1960 – General Chemical today opened extensive new production and packaging facilities for its line of Baker & Adamson "Electronic Grade" Chemicals at nearby El Segundo to serve the booming West Coast electronics industry.

# New General Chemical facilities...

## GENERAL CHEMICAL LIQUID ALUM PLANT "ON STREAM" AT EL SEGUNDO, CALIF.

LOS ANGELES, July, 1960—General Chemical has completed its newest facility for production of liquid aluminum sulfate at El Segundo, California. This is General Chemical's twenty-ninth plant providing dry or liquid alum for pulp and paper manufacture, water and sewage treatment and other uses.

## Top quality phosphoric acid soon to flow from new General Chemical plant at E. St. Louis, Illinois

ST. LOUIS, December, 1960—General Chemical reported today that its new wet-process phosphoric acid plant at E. St. Louis, Illinois, is rapidly nearing completion. Important engineering advancements will permit production of finer quality green phosphoric acid than any presently available. Substantial savings are forecast for users because the new product is cleaner, freer from solids, and easier to use.

## ⅓ INCREASE IN "GENETRON" CAPACITY TO COME FROM NEW GENERAL CHEMICAL PLANT IN ELIZABETH, NEW JERSEY

NEW YORK, N. Y., October, 1960—A third plant to produce its "Genetron" line of fluorinated hydrocarbons is now being built by Allied Chemical's General Chemical Division in Elizabeth, N. J., to serve East Coast refrigerant and aerosol propellant users.

## announced in '60... ready to serve you in '61

General Chemical continues to grow in order to serve industry's growing needs. This is evidenced by the many new plants and facilities we started or completed during 1960. From them will come increased production of the products highlighted here . . . other basic and special chemicals, too!

Promise of further growth is also inherent in the substantial expansion of our Research Laboratory at Morristown, New Jersey, which will be completed this year.

To learn more about the broad range of products we are geared to serve you with in the soaring 60's, write today for our free new brochure "Chemicals For Industry." Business letterhead, please.

Allied Chemical

**GENERAL CHEMICAL DIVISION**

**40 Rector Street, New York 6, N. Y.**

*Basic to America's Progress*


◀ **HERCULES'** Forster tells of $100-million CPI control effort in 1960.

**Thoughts that emerged from National Conference on . . .**

**√ Engineers will start thinking of water conservation as a design parameter.**

**√ Federal activity in control of pollution will increase.**

# CPI MAY FACE STIFFER POLLUTION LAWS

***Forces involved in water-pollution problems are working toward crystallization of a new national awareness that may reshape control measures.***

The National Conference on Water Pollution, held in Washington last month, didn't produce many new insights into the problem of our polluted waters. But it did serve to focus national attention on a problem that all agreed was getting worse. And as a sidelight, it provoked some spirited debate, between members of industry on one hand and conservationists and government officials on the other, on how our water should be used.

James M. Gill, plant manager of Ethyl Corp.'s Pittsburg, Calif., plant, spoke for industry when he told the conference that "dispersion and assimilation of wastes is an inevitable and proper use of receiving waters, provided other beneficial uses are also protected."

Disputing this basic contention of the industry delegation was Robert A. Forsythe, assistant secretary of the Dept. of Health, Education and Welfare, who told the meeting that "I fear there are some who believe that disposal of polluting waste is a legitimate use of water . . . (but) . . . it is quite clear that our goal now and in the years ahead must be to prevent any sort of water pollution, and our water pollution control laws should explicitly so provide."

And the industry assertion was subsequently beaten down when the conference adopted as part of its "national credo" the premise that users do not have an inherent right to pollute water.

▶ **What's Ahead for the CPI?**—Based on the results of the conference, the chemical process industries can look for governmental agencies—and especially the Federal government—to take a more active role in policing rivers and streams.

A crackdown on pollution-law violators will have two direct effects on the chemical engineer. He will be called upon to design better and cheaper waste-disposal plants. And water will become a more important factor in process design; there will be more emphasis on maximizing water re-use and minimizing sources of in-plant pollution.

And for chemical companies, it will mean increasing the investment in nonproductive equipment.

▶ **What to Look For**—The role of the conference was strictly advisory, and its recommendations, moderate as they are, are not binding. But congressional Democrats seem to be in a militant mood to push pollution control. And it is in Congress that many of the recommendations will have to be translated into effective action.

Essential features of the conference findings are summed up in the national credo: (1) users of water do not have an inherent right to pollute; (2) users of public waters have a responsibility to return them as clean as possible; (3) prevention of pollution is as important as control.

The conference also called for a national water policy, built around comprehensive planning for each river basin or water resource area, such as the work being done by the Ohio River Valley Water Sanitation Commission.

The final version of the conference's specific recommendations avoided such controversial issues as the role of the Federal government in setting water-quality standards, law enforcement, plant construction and research.

▶ **Not So Diffident**—Two members of Congress who have long been identified with the fight for cleaner water, however, are not so reluctant to spell out specific proposals for combating pollution.

Sen. Robert S. Kerr (D., Okla.) and Rep. John A. Blatnik (D., Minn.) both plan to introduce pollution-control legislation into the

**√ Federal and state laws will be standardized and strengthened.**

**√ Water dispersal is not a legitimate waste-disposal method. Or, as one wag puts it: dilution is no solution for pollution.**

new Congress. Both bills will emphasize an increase in federal research effort and an increase in the federal grant program for construction of municipal sewage plants. In addition, Blatnik wants to broaden federal enforcement authority to include all navigable waters and to set up a special pollution-control agency that reports directly to the HEW secretary, removing the responsibility from the Public Health Service.

A proposal to allow companies to deduct the cost of pollution-abatement equipment from their tax returns, as a "cost of doing business", does not seem to have won any great favor in Congress.

▶**What to Do**—The chemical industry has not been unaware of the pollution problem. According to Albert E. Forster, president of Hercules Powder, the CPI spent over $100 million last year to control pollution. Cities Service's new refinery in Bronte, Ont., for example, discharges waste water that is pure enough to drink (*Chem. Eng.*, Aug. 24, 1959, pp. 114-117). And Monsanto has just put a new waste-treatment plant on stream at Anniston, Ala. (see story that follows).

Increasing pressure to clean up and conserve water will not have a revolutionary effect on the chemical industry, but will accelerate trends that are already established. Plants and processes will be designed more with an eye to decreasing the amount of water required per unit of product.

Leonard Pasek of Kimberly-Clark Corp. recommended to the conference several specific water-conserving measures. Leading the list is an increase in water recycling. Industrial re-use of water is now about 100%; i.e., each gallon of intake water is used twice before discarding. Within ten years, that figure is expected to rise to 400% and CPI re-use will undoubtedly be higher.

▶**Go to Air Cooling**—Another water-saving trend is the use of air cooling. Its growing popularity is due primarily to lower maintenance costs, but it also saves water.

Salt water, which has been used with some success as a cooling medium, will probably find increasing acceptance. And in-plant water surveys and employee educational programs to reduce water consumption will become more popular. Installing water meters so that individual departments have to give a monthly water accounting has been found effective in conservation programs.

Treated municipal waste water can be used directly for industrial purposes where purity is not critical. And there will probably be more cooperative ventures between industrial plants and neighboring municipalities such as the arrangement between American Cyanamid and Bound Brook, N. J. Cyanamid recently constructed an activated-sludge treatment unit that serves both the plant and the community.

▶**Star Example**—Kaiser Steel's new Fontana, Calif., mill rates a gold star in every conservationist's book, for not only does it minimize water use but ends up by "swallowing" its own waste. The installation uses only 1,200-1,400 gal./ton of steel, just 2.5% of the industry average.

The mill achieves this through a combination of factors:

All cooling water is recirculated through cooling towers instead of being used once. Blowdown from cooling systems is re-used repeatedly in successive systems. Effluent from the plant sewage-disposal unit enters the cooling cycle. Finally, cooling water that has accumulated the heaviest pollution load is used for quenching slag, where it evaporates.—RAL

## ACTIVATED-SLUDGE PROCESS SOLVES WASTE PROBLEM

***Special bacteria, uniform air feed, enable new sludge system to successfully treat insecticide-plant wastes.***

At Anniston, Ala., last month, Monsanto Chemical Co. unveiled a new waste-treatment plant that has solved a sticky disposal problem resulting from a 50% expansion of its parathion production.

The new facility, which reduces the biochemical oxygen demand (BOD) of the plant wastes (containing paranitrophenol, organophosphorus compounds, various sulfides, etc.) from 4,000 ppm. to about 13 ppm., uses no lagoons, covers less than one acre of land and is operated by the parathion-plant production staff.

Before the expansion of parathion output, Monsanto's wastes were treated in the Anniston municipal sewage-treatment plant by an activated-sludge process originally developed by Monsanto in a pilot plant at Nitro, W. Va. Capacity of the municipal plant was not sufficient, however, to cope with more waste from stepped-up parathion output. Since the city did not wish to expand its treating facility

Air, fed from 690 diffusers, violently agitates waste in aeration basin.

to handle the increased flow, Monsanto had to install its own plant.

Under the direction of Clifford N. Stutz, pollution control engineer for Monsanto's Organic Chemical Div., the company obtained design data from a $20,000 pilot plant at Anniston handling straight parathion waste, undiluted by other types of sewage.

Using these data, Polyglaze & Basenberg, Birmingham, Ala., prepared detailed design drawings for use by Catalytic Construction Co., Philadelphia, in constructing an activated-sludge treatment plant.

This plant went on stream in September handling waste from the original parathion facility. By November, it had accepted, as well, the 50% increase in load from the expanded parathion unit.

▶**Raising the pH**—Raw waste liquor flows from the plant at 210 gpm. into a 150 × 50 × 6-ft. limestone neutralization pit where its pH is raised from about 1 to 6.8. Liquor then flows into two 7 × 7 × 9-ft. mixing chambers where it is agitated by turbine mixers.

Next, the waste flows through a blending tank 23 × 70 × 9 ft. A second tank is on standby to receive any spills or excessive loads. Contents of this tank are pumped back through the blend tank at a low rate. One tank is equipped with two rows of horizontal paddles turned at 4 rpm. by a 5-hp. motor.

▶**Treating in Aerators**—In the new system, flow from the blending tank is pumped to two 900,000-gal. aeration basins. Of reinforced concrete, these 235 × 35 × 16-ft. basins are separated by a Y-wall.

Waste is distributed uniformly to the aeration tanks by a system of weirs and channels. Three V-notched, adjustable weirs bring in the liquor. Four more weirs, alternated with the input ones, feed returned activated sludge from a nearby secondary settling tank.

Along the Y-wall of each tank are 690 diffuser tubes mounted on 15 swing arms. Each tube delivers air at 4-8 cfm. Compressed air comes from a bag-filter house and compressor system, the latter comprising three 150-hp. rotary blowers (3,000-cfm. capacity each).

Following aeration, the liquor flows into a 40-ft.-dia. x 8-ft.-deep concrete clarifier tank. A rake mechanism at bottom of the tank sweeps solids into a well from which sludge is pumped by two 200-gpm. centrifugal pumps that return it to the aeration tanks. Overflow from clarifier passes through a metering-sampling device, then discharges to the city sewer.

▶**Special Bacteria Used**—When starting up the plant, Monsanto trucked 80,000 gal. of sludge from Anniston's treatment plant. Waste-consuming organisms in the sludge had become acclimated to the waste from the parathion process. By using this sludge as seed, the new plant started without an extended acclimation period. Some of the bacteria present in this sludge were fully acclimated to straight parathion waste and needed only sufficient time to multiply to the number required to digest the full volume of waste.

Company engineers find that as long as the dissolved oxygen is maintained above 2 ppm. the plant operates smoothly. Regular dip samples are taken from the aeration tanks each day and checked for dissolved oxygen (DO) content.

The plant was designed to supply 2,000 cfm. of air/lb. of BOD. Aeration capacity is 30 cu. ft./lb. of BOD/day. Efficiency of this design reduces BOD 85-90% and removes 90-98% of phenolics.

Cost of the treatment unit was more than $400,000. However, it is expected to pay for itself through reduction in sewage bills previously paid to the city of Anniston.—AVG

## Computers Understand Written English

Two computers that read words —Remington Rand's UNIVAC and R.C.A.'s 501—have successfully operated under interchangeable English-language programs for the first time.

The necessity of preparing separate, costly programs for each make of computer has long plagued the electronics industry. Now, however, as a recent two-day demonstration established, a Common Business Oriented Language (COBOL) is practical.

Basically, COBOL is a programming system that employs simple English words for computer instructions, instead of the complicated, sometimes symbolic, codes presently tailor-cut for each make of computer. In some cases, use of COBOL halves conventional programming time.

COBOL's vocabulary includes a variety of nouns, such as *payroll file, employee number, tax,* and some twenty verb commands, ie., *write, divide, move.* Conjunctions and prepositions link verbs and nouns, and the word *if* instructs the computer to compare data and execute the resulting logical decisions. The words are transferred to magnetic tape and fed directly to the computer.


Levulinic acid is a novel ketone plus. It reacts not only as a ketone, but also as a carboxylic acid. The 1,4-spatial relationship of these functions frequently leads to cyclization to form heterocyclic types.

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### Potential Uses

This novel ketone offers rich potentials as evidenced by the many suggested uses entered in our recent big idea contest. Some of those ideas: Use as a solder flux; as a stabilizer for emulsions of organic insecticides; as a therapeutic source of assimilable calcium and iron.

### Availability

QO Levulinic acid is available from our Omaha, Nebraska plant in cans and drums.

**For further study of this polyfunctional compound, write for our Bulletin 301-A.**

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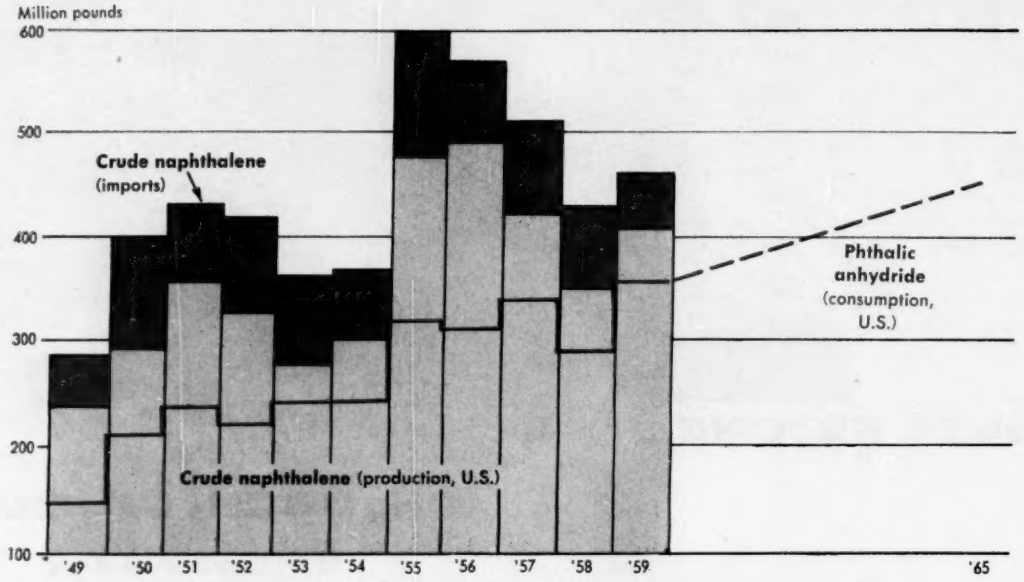


# STEADIER COURSE FOR NAPHTHALENE

*First capacity planned for petrochemical naphthalene should stabilize erratic behavior of existing coal-based supplies. And it should eventually transform today's short rations into a surplus that will make the U.S. a net exporter.*

G. E. NICKLAUS
*Universal Oil Products Co.*

The petroleum industry is planning to have available about 400 million lb./yr. of naphthalene capacity by the end of 1961.

Ashland Oil and Refining Co. expects its Hydeal* unit for naphthalene production to go on stream early in '61. Sun Oil Co. has announced the awarding of contracts for a hydrodealkylation unit and Tidewater Oil Co., together with Collier Carbon & Chemical Co., has announced plans for two units.

► **Stable Supplies**—Not only will large quantities of naphthalene thus be made available for the first time from the petroleum industry but, also, this will represent a stable source of supply for phthalic producers.

► **Fills Breach of Promise**—About a year ago, the long steel strike came to an end. At that time, optimism regarding economic activity was running rampant. The steel industry was to operate at or near capacity throughout '60 in order to rebuild stocks depleted by the long strike, as well as to meet current demand. Ample supplies of coke chemicals would, therefore, be made available relatively early in '60.

At year's end, naphthalene was still in short supply. The prognosticators had not anticipated steel production declining to 50% of capacity by July and remaining at a relatively low level for at least the remainder of the year. It becomes quite apparent that the shortage will be with us well into '61.

► **Readjustments**—There are many ramifications to increasing naphthalene supply by 400 million lb. of petroleum-based product over the short period of time between now and the end of the year. In the first place, the petrochemical product will not be the same material as that furnished by the steel industry. Petroleum naphthalene will probably be in the "refined" class rather than the 76-79° class that covers most of the naphthalene now used; the sulfur content will be exceptionally low and supply stable.

► **Price Question**—Any one of these factors would be sufficient reason for petroleum naphthalene to command a premium price over other naphthalene customarily used for phthalic. On the other hand, the availability of the additional naphthalene may well result in a temporary weakening of prices, at least until the market can again adjust itself to the new situation. The adjustment will take place primarily through increased domestic and export demand. In addition to the growth of current uses, the adequate supply will encourage the development of new ones.

There appears to be little hope of immediate relief for naphthalene users in the meantime. The steel industry is continuing operations at a very low rate, with no indication that this rate will be substantially increased over the course of the next several months. Imports also continue at a very low level.

► **Potential Stopgaps**—Of lesser importance to the naphthalene sup-

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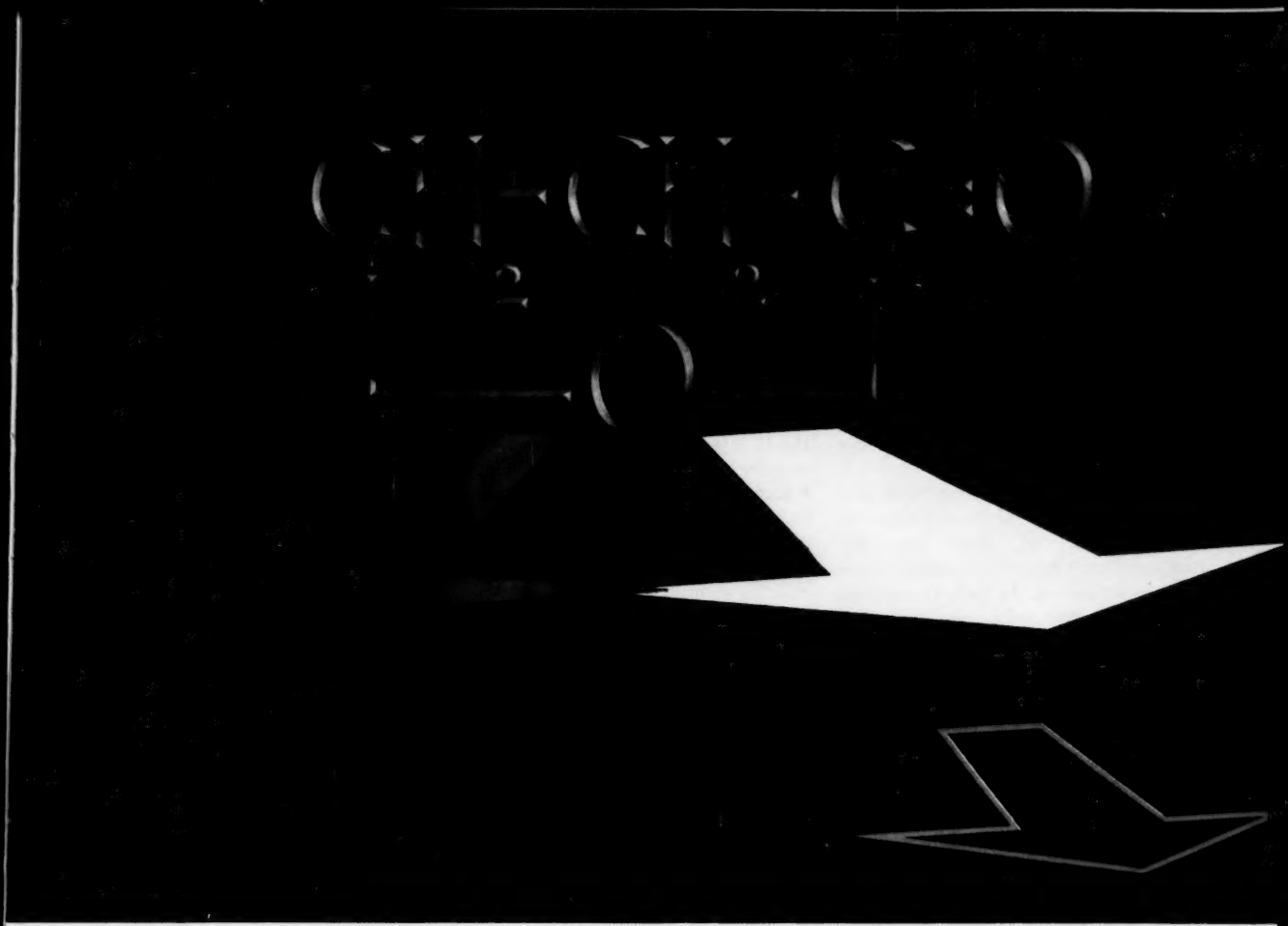

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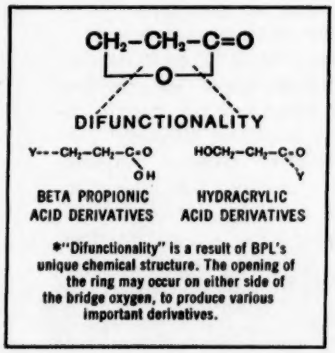


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ply picture is, of course, the potential production of phthalic from o-xylene and of isophthalic acid from *m*-xylene. At today's relative prices and techniques, the economics of using *o*-xylene rather than naphthalene are questionable. When naphthalene is in short supply, however, *o*-xylene can help alleviate the situation, and isophthalic acid may be substituted for phthalic in some uses.

Had the steel industry been able to operate at or near capacity throughout '60, there probably would have been adequate supplies of naphthalene. In fact, it has been reported that coke oven operators and tar distillers have or will have adequate capacity to supply the naphthalene requirements of the country throughout most of the '60's. But, although the capacity may exist, this is small consolation to the users of naphthalene, for there is no indication that the steel industry will be able to operate at a high rate in the near future.

In addition to the erratic behavior of steel production, the naphthalene users are faced with the threat of lower production of coke oven byproducts, because of technological innovations in the steel industry, which will reduce coke demand. Extension of fuel injection and oxygen enrichment to blast furnaces could reduce the coke rate about 25% and increase steel output from existing facilities some 30% (*Chem. Eng.*, Sept. 5, 1960, p. 48). At least partially offsetting the resulting reduction in naphthalene production is the possibility of increased recovery rates. If recovery rates were improved enough to obtain one pound of naphthalene per gallon of tar processed, this in itself would provide an effective counterbalance. It appears, then, that naphthalene production from the traditional source of supply could remain at approximately the same rate as it has in the past. Whether or not recovery rates improve enough to permit maintaining the same rate of naphthalene production will depend in great part on new competition from outside of the steel industry.

Imports can no longer be counted on. In the past, they furnished a sizable share of U. S. naphthalene demand. With foreign needs growing rapidly, imports have fallen off drastically, undoubtedly will continue at a very low level. Although this situation causes even greater aggravation, at the present time, for consumers of naphthalene, it bodes well for the future, because the U. S. probably will become a net exporter within the next few years.

▶ **Exporter-to-Be**—It is reasonable to assume that supply from coal tar sources will not get much larger. As noted earlier, changes in steelmaking techniques will definitely reduce metallurgical coke production. It is only a probability that the naphthalene recovery rate will be increased to offset, at least in part, the effects of lessened coke demand. In addition, many substitutes for steel have been developed and utilized that will prevent as rapid a growth in the steel industry as might otherwise have been possible.

Naphthalene production has averaged approximately 425 million lb./yr. from '55 through '59. However, during this same period, production has ranged from a low of about 345 million to a high of nearly 500 million lb./yr. Assuming a range of 350 to 550 million lb. from the steel industry and 325 million lb. from the petroleum industry, naphthalene supply after '61 could vary from 675 million to 875 million lb./yr. Domestic demand has been forecast at approximately 600 million lb. by '65 and 700 million lb. by '70; therefore, a fairly sizable amount for export will be available.

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## Now: Chemical Literature Information-Retrieval

The flurry of activity continues in American Society for Metals' information-retrieval subscription service. Items:

- Extension of coverage from the specifically metallurgical to the more broadly defined chemical literature.
- National Science Foundation's recent grant of $159,000 to Western Reserve University, which has been developing ASM's literature-searching unit.
- Expansion of the service's memory-stored library from 12,000 to 40,000 references—including U. S. patents.
- Completed transfer of punched-tape records onto magnetic tape for the new GE 304 searcher.

Spurred by the slowness, cost and incomplete coverage of manual literature-scanning (it's estimated that industrywide mechanized literature-searching could save $500 million annually), ASM's Metals Documentation Service is designed to survey published literature.

In response to a specific question, encoded by experts after consultation with the subscriber, the machine returns a list that shows where relevant information can be obtained. This is not an abstract of document contents, just a statement of which ones are likely to be helpful.

Four types of service are now available. The most immediate is one ASM calls "current awareness": a biweekly search of all new documents pertaining specifically to the subscriber's problem or research area. A second service is bibliographic or retrospective search of the machine's total memory (currently, only two years have been taped). The third: for those who want to install a searching machine in their own plants, tapes containing a year's encoded literature will be for sale. And fourth: "generic searches", similar to either the first or second service, but cheaper since the questions will be far broader, not custom-tailored.

By early 1961, ASM promises operation of a larger and swifter (100,000 documents per hour) "information searching selector," now being built by General Electric. For the interim, GE has programmed a GE 304, which last October replaced the original Western Reserve experimental searcher. Presently, encoding of back and current literature is going on at a rate of about 3,000 documents a month; eventually, ASM plans to have a complete library of all published documents in the metallurgical and closely related fields.

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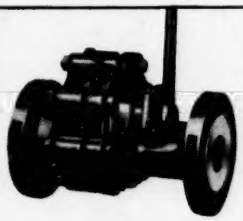

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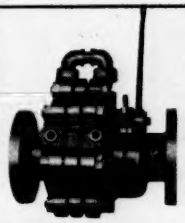

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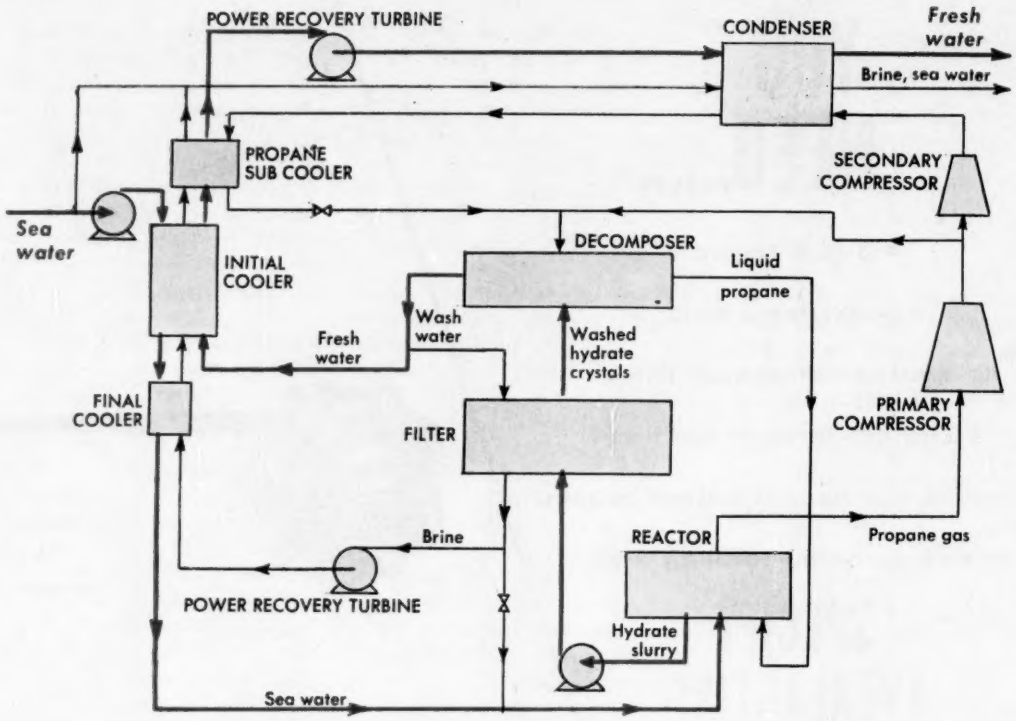


# ADD THREE TO SALINE WATER TECHNOLOGY

***Hydrocarbon-hydrate process and two new heat-transfer methods expand sea water conversion technology.***

Saline water conversion is in the news again with the unveiling of one new conversion process and two new heat-transfer techniques.

▶**Hydrate Process Unveiled**—W. G. Knox of Koppers Co. gave chemical engineers their first look at the hydrocarbon-hydrate process for saline water conversion in a paper presented at the recent AIChE national meeting in Washington, D. C. This process, which separates fresh water from sea water by formation of a propane-hydrate slush, compares favorably with freezing processes because its energy requirements are lower.

As shown in the diagram, sea water is pumped into the process, then is fed to the reactor after heat exchange with the product water and effluent brine. In the reactor, which operates at about 35 F. and 57 psig., the sea water is mixed with liquid propane, whereupon a slurry of clathrate (latticelike) crystals forms. The hydrate has a composition of about 17 moles of water to 1 mole of propane.

The slurry, containing 10-15% hydrate crystals, passes to the filter-washer, where washed crystals and brine are produced. Part of the brine is recycled and remainder discharged after heat exchange with feed and propane.

The crystals pass to the decomposer where they melt to form immiscible layers of saltfree water and propane. Decomposition is accomplished by pressure reduction and heat. Product water discharges after heat exchange with the feed and propane recycle and after a degassing operation. Liquid propane recycles to the reactor.

Propane is kept liquid by a two-stage refrigeration system—a low-temperature primary and a high-temperature secondary.

Propane vaporized in the reactor by heat of formation is compressed by the primary compressor and condensed in the decomposer, where it supplies the heat for decomposition.

Excess vapor from the primary compressor is further pressurized by the secondary and is condensed and subcooled by the fresh water product, brine effluent and additional sea water. Heat removed here represents energy input to the compressors, heat leaks, and sensible heat difference.

▶**Why Propane?**—Propane was selected from among many possible hydrate formers because of sev-

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eral features: hydrate-formation rate is satisfactory; pressure and temperature conditions are economically attractive; propane can be used as a direct heat-transfer medium; it has low water solubility; it is cheap.

▶**Economic Advantages**—A comparative study between the hydrate process and the butane-freezing process (the latter is described in *Chem. Eng.*, June 13, 1960, p. 152) showed that the energy requirements of the hydrate process are 28% lower. The energy saving is due to the smaller heat load in this process, which operates at higher temperature, and to propane being a more efficient refrigerant than butane in this temperature range.

Koppers estimates, on the basis of the standard Office of Saline Water estimating procedure, that its process will produce fresh water from the sea at less than 50¢/1,000 gal. in a 10,000,000 gpd. plant.

▶**Future Plans**—Koppers has so far operated its patented process only in a bench-scale unit, built under a cooperative agreement with OSW. The objective of this work has been to obtain engineering data for design of a pilot plant and for an eventual commercial-scale plant.

▶**Heat Exchange by Oil**—The first of the new heat-exchange techniques is radically different from present techniques—heat is transferred by circulating an immiscible oil between the cold sea water feed and the hot effluent in an evaporation process. Advantage: elimination of conventional heat exchangers, which are subject to scale and corrosion in sea water conversion processes. The new idea was described by T. Woodward of Food Machinery and Chemical Corp. in another AIChE paper.

The process takes place in a spray column similar to that used in liquid-liquid extraction — indeed, the operation is essentially a liquid-liquid extraction in which the extracted quantity is heat.

Oil is introduced into the column below a distribution plate and passes upward through the plate, which breaks it into small droplets. The droplets rise through the column, countercurrent to the hot water stream, and are collected at the top. From here, the oil is transferred to another similar column where it gives up its heat to the sea water feed. Water enters and leaves the columns through pipe distributors below the top interface and above the bottom interface.

Essential characteristics of a heat-exchange fluid for this process include: extremely low water solubility; rapid disengagement of any emulsion; chemical stability up to at least 250 F.; high heat capacity; low vapor pressure; low viscosity; no odor or taste; no toxicity; low cost. FMC has found that the best fluids are *n*-paraffins in the $C_6$-$C_{10}$ range. These materials must be highly refined to remove odor and taste elements.

Heat-transfer coefficients obtained so far in a double column exchanger have been about 2,500 Btu./hr., cu. ft., °F. This compares with about 300 Btu./hr., sq. ft., °F. in a conventional shell-and-tube exchanger. Thus, 1 cu. ft. of mass-exchange column is equivalent to about 8 sq. ft. of conventional exchange surface.

A direct cost comparison is not possible at this time, but it appears that the most expensive item in the new process will be the oil dispersion plates. FMC expects that if a cheap method of producing these plates can be found, the cost of spray columns should be much less than an equivalent shell-and-tube exchanger.

▶**Heat Transfer by Sound**—Southwest Research Institute has announced the results of another OSW-sponsored heat-exchange project. Here, heat-transfer coefficients in conventional exchangers are improved by acoustical vibration. Coefficients at Reynolds numbers in the 12,000 range are increased 26% by vibrations at 42 cps. and 0.15 in. amplitude. At lower Re's, coefficients increase by as much as 400%.

This technique is of prime interest in the saline water field because it has the bonus advantage of reducing scale formation on heat-exchange surfaces. SwRI's W. E. Thompson feels that the technique holds promise for a host of other industries and that this is borne out by the variety of inquiries he has received.

Watch for a feature article in a forthcoming issue of *Chemical Engineering* on the effects of vibration on heat transfer.—JRM

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## FIRMING UP UNSTEADY STATE

***At Nation's capital, chemical engineers learned more about their role in process control, during 12th annual Institute Lecture and packed technical sessions.***

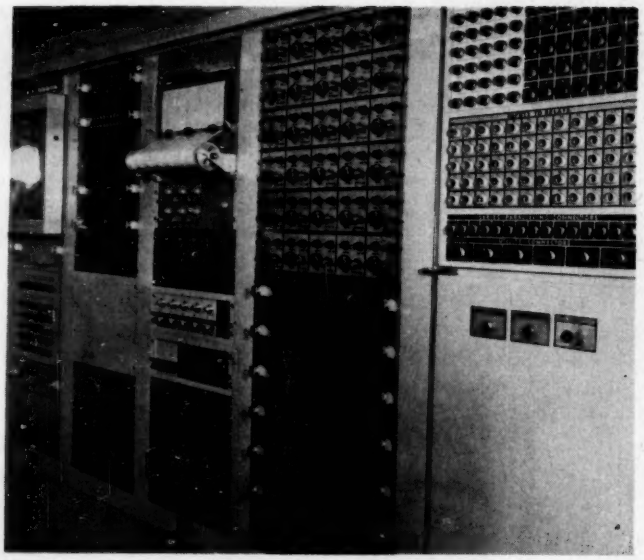
One mark of how process control has reached new prominence in the thinking of chemical engineers was the attention paid to it at last month's AIChE meeting in Washington.

Leading off, in a role of honor, technologist Joel Hougen, Monsanto Chemical Co., delivered the 12th annual Institute Lecture on "Process Dynamics—Accomplishments and Prospects."

Then, in three successive half-day sessions, control specialists focused the attention of the chemical engineer audience on technical aspects of this field.

▶**Stating the Theme**—Hougen's keynote talk set the tone of the meeting: "Reduction of the concepts [associated with process dynamics] to practice continues to be one of the most challenging chemical engineering enterprises in our time."

But in presenting the challenge, Hougen—who is a chemical engineer—warned that "these concepts still have to produce an appreciable impact on the CPI."



**Inside Monsanto's mobile data logger, described at AIChE meeting.**

Noting the tardiness of chemical engineers in entering this area, and, by implication, fixing this as cause for the slow spread, Hougen said: "A large part of the work dealing with process dynamics has been reported by others outside our profession. I feel we are falling short in our acquisition of process understanding by neglecting the fundamental importance of process dynamics."

Mincing no words, he blasted the lack of information available in the literature to guide engineers: "In 800 papers written on process control and dynamics during the last 20 years, few have really contributed any new ideas or unique methods of process control that were markedly superior to existing schemes.

"Only a handful contain much of substance in them; the great majority appear to be popular descriptions extolling the virtues of various techniques and dealing in generalities. Where information is divulged, it is so fragmentary, diluted or disguised that it can give others only a modicum of assistance."

Contrasting this with the worldwide attention to control, particularly Soviet Russia's, Hougen indicated that an analysis of papers presented at the IFAC Congress (*Chem. Eng.*, Sept. 19, 1960, pp. 181-6) showed the following breakdown of effort: 22.4% to studies of real systems, 12.8% to studies of hardware, 16% to nonlinear control, 13.2% to linear control and the rest to computer control, adaptive control, etc.

▶ **Lag in Understanding**—Warning that chemical engineers seem unaware of it, he said: "I cannot but feel that we in the U. S. are not making progress in applying process dynamics commensurate with our talent, facilities and capabilities. The tremendous impetus within Russia being given automation in general, and process dynamics in particular, is a sobering development. Over 7% of Russian scientific personnel are working in the field of control; 5,000 control engineers are completing academic studies every year."

Suggested causes of our lag:

- Failure to recognize differences between chemical processing systems and those encountered in other fields.
- Too much technique, not enough emphasis on improving economics.
- Lack of central agency to act as source of information, clearinghouse for ideas and guidance.
- Inadequate educational programs.
- Inadequate methods for procuring experimental information.

To show what dynamics can do for the chemical engineer, Hougen cited three areas of use: obtaining fundamental data on equipment for better scaleup and design; contributing to knowledge of physical and chemical phenomena in processes; identifying improper behavior in on-stream plants for better performance and control.

And he drove the message home by telling, both in the Institute Lecture and a later technical paper, how Monsanto has exploited some of the techniques in engineering practice. His technical paper, coauthored with R. A. Walsh, described advantages and limitations of pulse testing. Claimed Hougen: "Monsanto's experience with pulse testing has been found successful across the board from components to full-scale plants. It has yet to fail to yield useful dynamic data."

▶ **A Full Technical Program**—In yet another paper, Monsanto engineers J. F. Draffen, J. B. Jansen and M. O. Bird of the firm's Texas City plant described brief experience with a mobile data logger, collecting data by magnetic tape recording for later analysis by digital computer.

Shell Development, too, told of its long (9-yr.) experience with loggers. In its mobile unit, designed to collect dynamic data from operations such as columns, furnaces, compressors and turbines, Shell has gotten usable data about 30% of the on-line time.

Other papers taught (i.e., status of various types of instruments, advantages and disadvantages of testing techniques and analysis) and many engineers listened.

If plans of the Institute's process control program committee bear fruit, and results of the Washington meeting indicate they probably will, chemical engineers will hear more of, and hopefully contribute more to, the growing body of work in this area.—WCS

# SEL-REX RECTIFIER HELPS MAKE THE "LUBES" THAT KEEP MISSILES FROM BEING EATEN ALIVE!

At Hooker Chemical Corporation's Niagara Falls, N.Y. plant, a Sel-Rex rectifier supplies the current for an electrochemical operation important to the U.S. Space Program. It is production of fluorine, basic element of Hooker Fluorolubes®.

Polymers of trifluorovinyl chloride, Fluorolubes are made as non-flammable light oils, heavy bodied oils and greases. Their job is to protect missiles from their own corrosive chemical fuels—the metal-eating, highly-destructive action of pure oxygen, hydrogen peroxide and concentrated nitric acid.

According to Robert F. Schultz, production manager of Hooker's Eastern Chemical Division, the unit supplying current to the fluorine cells must provide uninterrupted, trouble-free service. To date, his Sel-Rex silicon rectifier "has met all expectations; it has proven completely reliable, presenting no maintenance problems and requiring little or no attention."

And for *your* special current needs—for reliable, continuous conversion of A.C. to D.C.—choose Sel-Rex, the industry-proved rectifiers that more than pay for themselves in unequalled dependability and maintenance-free service.

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*A slippery blanket of Hooker-made Fluorolubes protects missile parts, serves as a lubricant, sealant. A Sel-Rex silicon rectifier supplies the current required to make fluorine, an essential ingredient. "Our Sel-Rex rectifier," states a company official, "has given us the high standard of dependable performance required for our operation."*

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## CPI News Briefs

- Processes
- Plants
- Offices
- Companies
- International

### Processes

**Spheroidized particles of metals,** ceramics, radioactive materials, etc., are being produced by Thermal Dynamics Corp. by two processes: (1) melting powdered material with Plasma Flame torch at temperatures up to 50,000 F., chilling into spheroid form; (2) heat-slicing spheroid shapes directly from rods, wires or sheets, quenching molten particles in coolant gas streams in the chamber. Via the first process, materials such as zirconia yield as high as 95-99%-melted particles, 85% of them completely spheroidized. Powders may be processed in open air as well as in controlled atmospheres.

**Lead** can be salvaged 99.75%-pure from automobile storage batteries by means of a Hungarian process developed at the Institute for Nonferrous Metal Research of Budapest, in conjunction with Factory for Metals Alloys, also of that city. Key to the smelt process is the addition of sodium hydroxide and sodium sulfide during both steps of a two-stage refining. First stage takes place at 350-400 C., second stage at 600 C. Constant stirring (with a chrome-nickel plated mechanism) is necessary.

**Free oil acids** of 99% purity will be produced commercially in Austria soon, thanks to a new method for separating saponifiable and and nonsaponifiable oil acids. Only certain crudes from Venezuela, Rumania, and Austria are suitable for this patented naphthenic-acid extraction process. But Oesterreichische Mineraloel Verwaltungs A.G. (the state-owned oil concern) plans an immediate installation in the Schwechat refinery near Vienna. Basic process involves deacidizing crude oil and fractions with aqueous sodium hydroxide solutions, continuously evaporating the light components under atmospheric pressure, constantly maintaining liquidity without foaming.

**Low-nitrogen steel** is being produced commercially by Steel Co. of Wales under a new steelmaking route that SCOW has dubbed the VLN (Very Low Nitrogen) process. Product, containing as low as 0.001-0.002% $N_2$, results from 100% steam-oxygen blasts, directed into the bottom of scrap and pig iron converters. SCOW insists its VLN differs "substantially" from the Austrian L-D process, although no further details have been disclosed.

### Plants

**California Gas Transmission Co.,** Los Angeles, a subsidiary of Tennessee Gas Transmission Co., Houston, has filed an application with the California Public Utilities Commission to construct and operate the Southern California section of a $225-million natural-gas pipeline proposed for the Southwest.

The over-all pipeline project is based on a 1,592-mi. route through Texas, Mexico and California. About 75% of this route lies in Mexico, and a major backer of the project is that country's oil and gas agency, Pemex.

The section that California Gas Transmission is interested in would start near Mexicali, on the California-Mexico border, and would terminate at electric generating plants near Los Angeles. Facilities would include 292 mi. of pipeline and 10,000 hp. in compression equipment. Cost: $50-million.

**Mid-America Pipeline Co.,** Tulsa, Okla., reports that construction is virtually complete on its 2,200-mi. LPG pipeline connecting the Texas-New Mexico area with Minneapolis and St. Paul, Minn., and southern Wisconsin. Initial capacity is 50,000 bbl./day; ultimate capacity will be over 85,000 bbl./day. Distribution stations along the pipeline are at Greenwood, Neb.; Kearney and Moberly, Mo.; Sanborn and Iowa City, Iowa; Pine Bend, Minn.; and Janesville, Wis.

**Tennessee Oil Refining Co.,** division of Tennessee Gas Transmission Co., Houston, has awarded contracts for installation of aromatics production facilities at its Chalmette, La., refinery. This marks the firm's first venture in petrochemicals. Facilities will include a 6,000-bbl./day catalytic reformer, a 2,000-bbl./day extraction unit to produce benzene, toluene and xylenes, a 22-million-lb./yr. orthoxylene fractionation unit and a 20-million-lb./yr. ethylbenzene fractionator. The reformer and orthoxylene unit will be built by Bechtel Corp., San Francisco, the other two units by Badger Mfg. Co., Cambridge, Mass. Project completion is expected by the middle of this year.

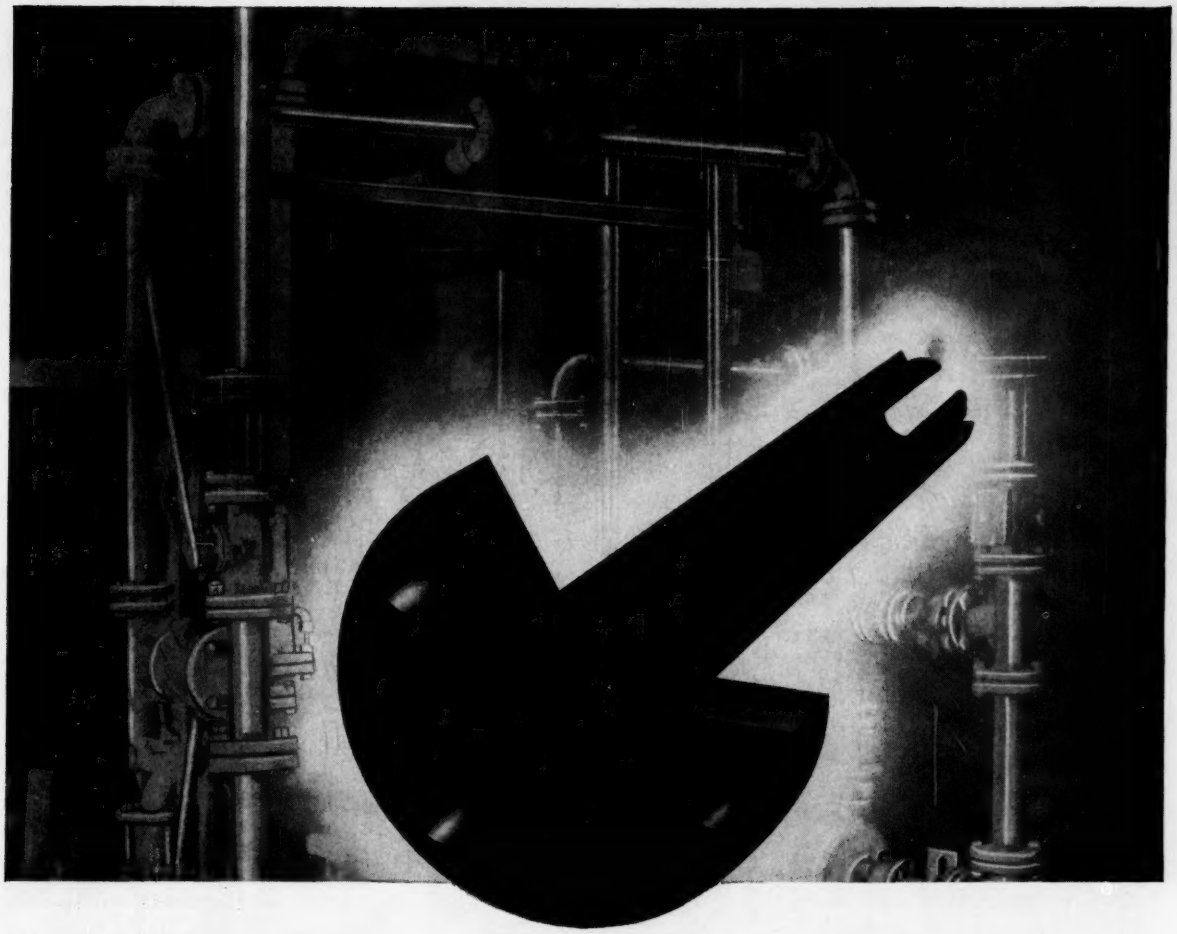
**Monsanto Chemical Co.** announces it is installing the West Coast's first manufacturing facility for phenolsulfonic acid, at its plant at Avon, Calif. Unit is scheduled to be on stream in March; it will increase Monsanto's capacity for the acid by 50%. The product is currently made by the firm at its Monsanto, Ill., plant.

**University of California at Los Angeles** has put into operation the world's first high-power spiral ridge cyclotron. Unit has pole tips 49 in. in diameter, features a spiral cloverleaf design that permits continuous acceleration of protons, in contrast to the bursts of acceleration provided by current synchro-cyclotrons. It can accelerate atomic particles to 50 million electron volts.

**Sun Oil Co.** announces it will build a new gas plant at its Marcus Hook, Pa., refinery. Over-all project, including tie-in with existing

More CPI News Briefs

*(continued on page 170)*



# Plant saves $60,000 per month by switch to pipe lined with TEFLON®

In a plant manufacturing a chemical intermediate, excessive maintenance costs and product losses ran as high as $60,000 per month. Such frequent failures occurred in the process involving corrosives at high temperatures and pressures, that onstream time averaged only 75% during the first six months of operation. After a period of testing, more than 1500 feet of pipe lined with Du Pont TEFLON TFE-fluorocarbon resin were installed. Result: No failures of lined pipe occurred in over 2 years of service.

TEFLON TFE resins are unaffected by HCl liquid and vapors, fuming nitric acid—white or red—hydrofluoric acid, organic solvents and reagents. TFE resins are rated for use up to 500°F. Their non-adhesive surfaces prevent plugging by high-viscosity materials. TFE resins do not shatter under vibration, thermal or physical shock.

The liner flared over the flanges provides protection for the steel from the process fluid and eliminates the need for additional gasketing. Installation costs are further reduced because the pipe is equipped with standard flanged fittings which are easily connected. And the need for careful aligning, hanging, welding and other special procedures is eliminated.

In your chemical processes, you can insure long service life and greatly reduced maintenance and downtime by installing pipe lined with TEFLON TFE resins. For more details on properties and performance send for the new bulletin on Lined Pipe . . . and for more general information, ask for the fact-filled booklet, "Designing with TEFLON". Write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department CE-123, Room 2526T, Nemours Building, Wilmington 98, Del. **In Canada:** Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

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*TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resin.*

## PROTECTIVE SILICONE LENGTHENS LIFE OF ELECTRONIC COMPONENTS

Silicone potting material, almost as dense as water, cures to this transparent, shock-resistant solid at 25 C.

Electronic components can be imbedded into a new solventless silicone polymer as easily as fruits into a cup of gelatin.

Although this potting material is a methyl silicone of 100% solid content, it is easily poured at room temperature (at 25 C., the viscosity ranges from 800 to 1,500 cp.) and flows freely in and around complicated parts. After a 16-hr. cure at 75 C., the liquid becomes a transparent and flexible solid that protects the imbedded parts from shock, vibration, moisture, ozone, dust and other environmental hazards.

Called LTV 602 (low-temperature vulcanizing), this silicone will also cure at room temperature in approximately 72 hr. and, because of its negligible shrinkage, won't stress-damage delicate parts.

Components imbedded are readily identified and can be repaired or replaced by removal of a section with a sharp knife. New material poured in the cutout section then cures without leaving evidence of repair.

LTV's resilience prevents damage to potted components subjected to thermal cycling from −65 to 125 C. At low temperatures, there is no significant effect on the physical properties of the potted units except an increase in hardness. High-temperature aging (175 C.) gives LTV increasing firmness, and Shore A durometer tests show that this silicone compound remains resilient even after aging 1,800 hr.

Other studies indicate that LTV 602 protects continuously at 150 C., has a life expectancy of over 3,000 hr. at 175 C. and 1,000 hr. at 200 C. and cures satisfactorily over most of the insulating materials found in electronic assemblies.—**General Electric Co., Waterford, N. Y.** 94A

## Styrene plastics

**Lightweight ABS plastic features toughness and easy processing.**

Produced by graft polymerization, Lustran resins are the latest materials to join the ABS family.

As copolymers of acrylonitrile and styrene, and terpolymers of acrylontrile, butadiene and styrene, these Lustran resins would hardly be classified as new materials. But evidently Monsanto Chemical Co. has perfected graft polymerization techniques so that a high degree of molecular control can be imparted to the resins, permitting them to meet almost any desired specification. (Grafting of an existing polymer onto a main polymer chain usually occurs when radical-type initiators such as hydroperoxide groups, $\beta$ or $\gamma$ radiations create enough radicals to start the reaction.)

Specifically designed for molding and extrusion, Lustran resins are said to combine excellent rigidity, toughness and high tensile strength. They resist abrasion as well as metals do and show superior thermal stability.

One particular resin is reported to have 10 times the impact resistance of styrene and 4 times that of rubber-modified styrene. These resins will be used in automotive parts, household appliances, pipe fittings and other fields, in which they will compete with established ABS plastics.

Currently produced at the rate of 6 million lb./yr., Lustran sells from 37 to 51¢/lb. but will probably adjust to new price levels at the end of this year when Monsanto completes a new 50-million-lb./yr. plant at Addyston, Ohio.—**Monsanto Chemical Co., N. Y.** 94B

## Varnish

**Liquid silicone withstands heat, cures quickly.**

A new dipping and impregnating silicone varnish, Dow Corning 981 Varnish, eliminates high-tem-

# D. I. S. STRIPS 10-INCH SCALE FROM 12-INCH PIPELINE IN JUST ONE DAY!

**Dense scale deposits** of oxides, sulfides and sulphur—10 inches thick in some places—clogged a 12-inch fuel supply line. Dow Industrial Service engineers stripped every trace of deposits from this 750-foot pipeline—restoring full capacity—in *just 24 hours!*

**Solvents and a pipeline pig** did the job. But for different conditions, D. I. S. uses other techniques to get the same result. For example, when scale blocked a 24-inch, quarter-mile-long waste line, D. I. S. engineers knocked out the deposits with a special D. I. S.-designed jet mole. Though this underground pipeline was buried 10 feet deep, D. I. S. cleaned it completely in only 16 hours!

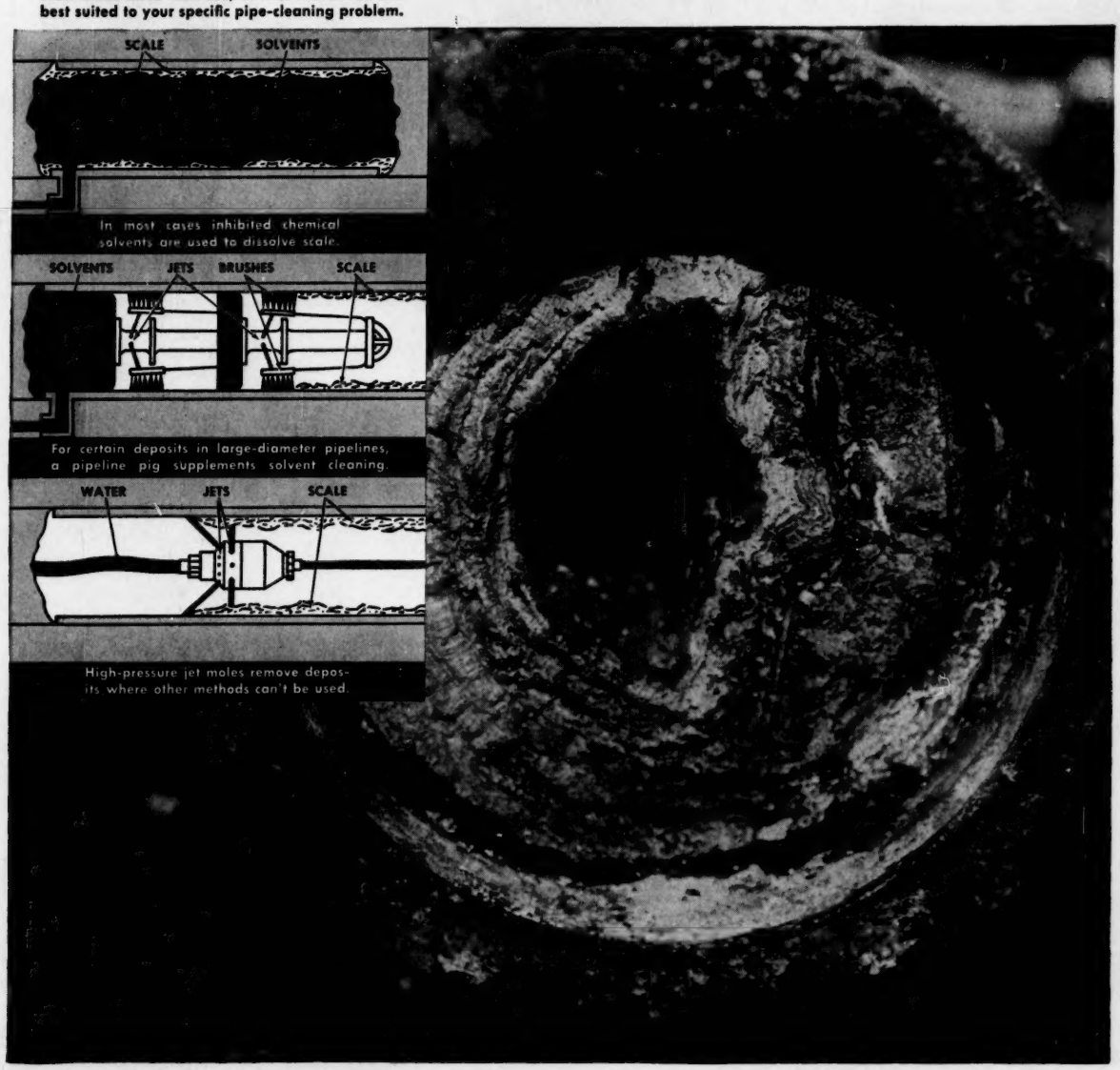
**Nation-wide Dow Industrial Service** first analyzes the job to be done, then selects the technique which will do the best job, fastest. D.I.S. cleans all kinds of lines—fresh water, boiler feed-water, gas, waste and other lines—and every kind of process and heat exchange equipment.

In addition, D. I. S. offers complete consulting laboratory service for water treatment and waste processing problems, backed by the technical resources of The Dow Chemical Company. For cleaning *any kind* of equipment, *anywhere* in the U. S., write or call DOW INDUSTRIAL SERVICE, 20575 Center Ridge Road, Cleveland 16, Ohio.

DOW

**DOW INDUSTRIAL SERVICE** • Division of The Dow Chemical Company

**From these three methods, D. I. S. selects the one best suited to your specific pipe-cleaning problem.**



perature curing in producing Class H electrical equipment, because it develops most of its final bond strength at 150 C. in only 6 hr.

Despite the lower curing temperature—50 C. below that required for similar silicone products—981 Varnish has enough heat stability to meet AIEE Class 220 C. service.

Suitable as a universal varnish, this dark brown silicone liquid can be used for all insulation classes of motors and transformers.

The normal butyl alcohol solvent has several advantages over the xylene and toluene that are blended as solvents with other silicones. The second coat of 981 Varnish won't lift or wrinkle over the first coat and cured varnish will not soak off impregnating racks and handling equipment to contaminate the varnish tank. Moreover, this solvent won't affect most insulating materials including silicone rubber.—**Dow Corning Corp., Midland, Mich.** **94C**

## Polyethylene

**Carbon black dispersion makes the resin moistureproof.**

A black pigmented polyethylene, known as Petrothene 201-220, is a light (density 0.916) resin that resists water seepage and won't even require drying before extrusion, because of its originally low moisture content.

The homogeneous carbon black dispersion also gives the resin a lightproof barrier that is required in agricultural mulch paper and in packages for photographic film. Resistance to light and moisture is retained even in coatings as thin as 0.75 mil (19 micron).

With a 4-5.5 melt index, Petrothene is especially suited for coating paper, paperboard and aluminum foil. Its adherence to paper is reported as excellent, but the resin requires a primer for good adherence to aluminum foil. Extrusion temperatures of 590-610 F. are recommended for best results. **U. S. I. Chemicals Co., N. Y.** **96A**

## Aluminum-epoxy system welds metals in 45 min.

*Introduced at the recent Production Engineering and Machine Tool Builders Show, Devcon F is reported as the strongest, most versatile repair material available today.*

*Made of 80% aluminum and 20% epoxy resins and modifiers, product adheres tenaciously to steel, iron, aluminum, bronze and glass surfaces, thus repairing castings, valves, pumps and all sorts of equipment.*

*Packaged like a toothpaste, Devcon F is squeezed out of the tube, mixed with the supplied hardening agent and applied to the broken casting or part to be repaired. At about 150 F., complete welding occurs in less than 1 hr. at considerable savings in lost production time.*—**Devcon Corp., Danvers, Mass.** **96B**

## Newsworthy Chemicals

### Page number is also reader service code number



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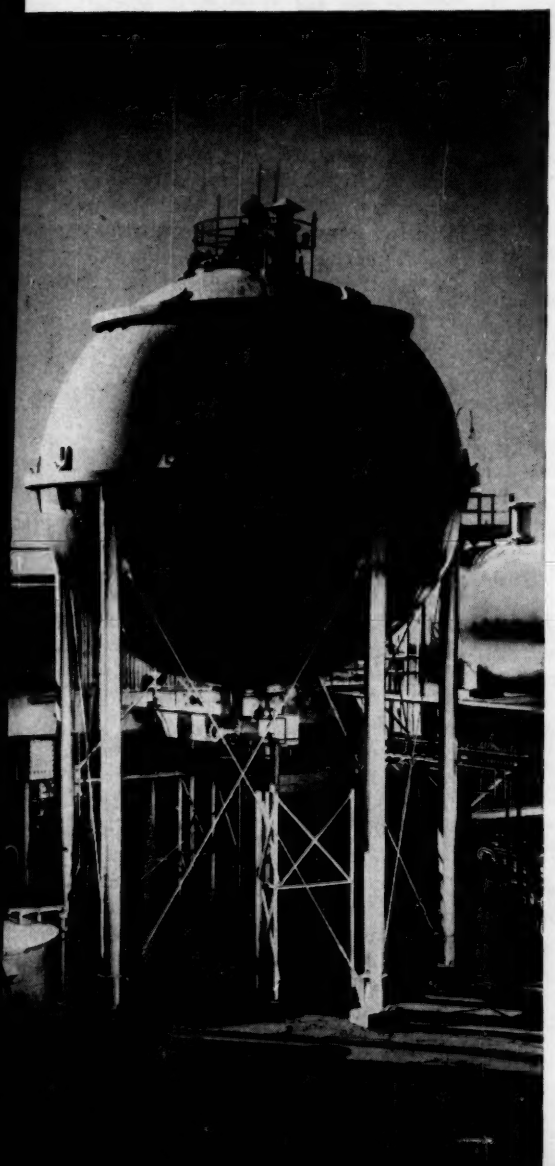
# WHEN YOU HAVE TO HOLD THE COLD...LET PITTSBURGH-DES MOINES CRYOGENIC STORAGE VESSELS DO THE JOB FOR YOU!



5,000,000 scf 28 ft OD LOX Storage Sphere. Baldwin Park, Calif.

As a pioneer in cryogenics and holder of a number of patents in this specialized field, Pittsburgh-Des Moines brings years of experience to the design and fabrication of storage units exactly meeting your requirements. Particularly valuable is PDM's welding know-how with aluminum, stainless and alloys for extreme low temperature duty. In addition, several completely equipped fabricating plants coast-to-coast assure prompt service wherever your job locations may be. Write us!

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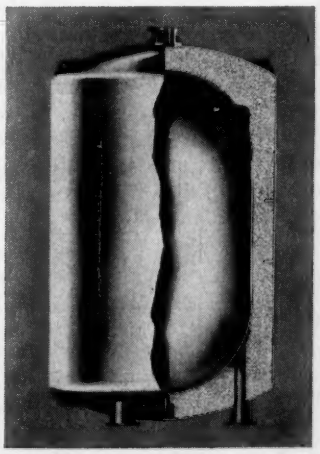
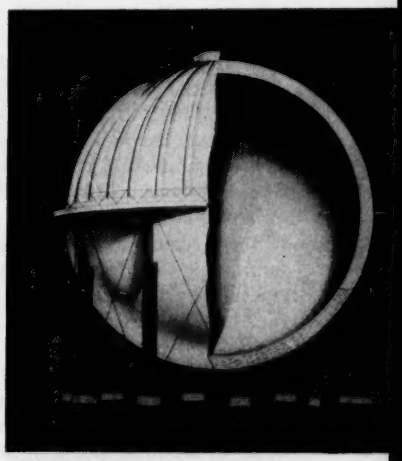
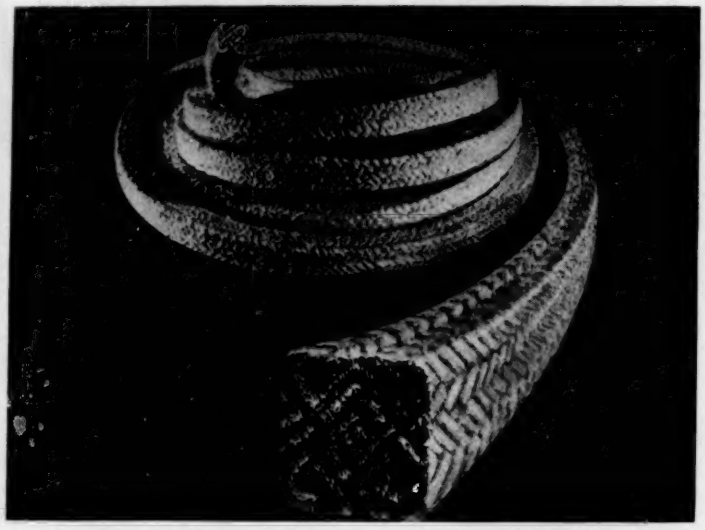


One of 25 LOX Storage Tanks—9% Nickel Inner Shell



Cutaway of 45 ft 10 in. PDM Insulated Double-Shell Sphere

## Teflon-asbestos marriage begets low-price packing



*Although excellent as a packing, Teflon is often avoided because of its high cost. But thanks to a new process that impregnates asbestos with Teflon, a good packing material is now available at approximately 40% below current national prices.*

*Called Style 5875, this material—braided white asbestos with more than 30% Teflon by weight—has widespread application on rotary and centrifugal shafts, valve stems and expansion joints, reciprocating rods, plungers and rams. Because of its low coefficient of friction, Style 5875 reduces wear to the packing and to mechanical components during startup and operation, withstands temperatures ranging from —90 to 500 F. And, it remains unaffected by acids and alkalis.*—**Garlock, Inc., Palmyra, N. Y.** **98A**

## Epoxies

**Self-extinguishing resins begin to move out of experimental stage.**

Bromine halogenation has been found more efficient than chlorination in making two epoxy resins self-extinguishing. The resins, X-3442 (49% $Br_2$) and X-3441.1 (19% $Br_2$), hardened with common curing agents, can be blended with liquid epoxies to make self-extinguishing castings.

Both resins give castings and laminates that have physical and electrical properties comparable to those of conventional epoxy resins. Usually, fire retardance is acquired without degradation of the mechanical or electrical properties; at 300 F., however, all systems containing these brominated epoxies lose approximately 50% of their initial flexural strength.

Blends with novolak resins are expected to result in higher modulus even at elevated temperatures.

These brominated systems, still at the experimental stage, hope to find a market in laminated aircraft structures, glass- and paper-based electrical circuits, filled castings, aircraft and missile adhesives. Initial prices range from $1 to $2.01/lb.—**The Dow Chemical Co., Midland, Mich.** **98B**

**For More Information about any item in this department, circle its code number on the Reader Service Postcard (Page 203)**

## *Briefs*

**Paint thickener** Cellosize QP-15,-000 promises drastic reductions in the time and attention needed for thickening exterior and interior paints. Because of its high solubility and delayed thickening action, Cellosize can be safely added without causing clumps, globs or tacky mixtures—**Union Carbide Chemicals Co., N. Y.** **98C**

**A new primer,** Armitage P-289, for plastisols, organosols and textured vinyl finishes claims excellent color retention and resistance to salt spray and humidity. Applied by spray or dip coating, it adheres strongly to substrates such as steel, aluminum, galvanized metal and glass. Drying time is about 5-15 min.—**John L. Armitage & Co., Newark, N. J.** **98D**

**Anionic-nonionic emulsifiers,** Agrimul A-100 and N-100, blend in almost all chlorinated insecticide concentrates in current use. The nonionic content of both emulsifiers is due to an ether-linked surfactant that contributes long shelf-stability to the concentrate, making it stable even when diluted in hard water.—**Nopco Chemical Co., Newark, N. J.** **98E**

**Plating brightener** for zinc-plating baths now allows zinc to reach low-current-density areas such as recesses and threads. Called Brightener 25, the new liquid gives crystal-clear zinc deposits on case-hardened or hot-rolled steel and may be added directly to plating baths without prior dilution.—**Metal and Thermit Corp., Rahway, N. J.** **98F**

**A quinacridone** with a brilliant red-violet hue, Quinto Magenta RV-6803, is a new nonbleeding pigment for automotive finishes, inks and plastics. It gives red shades with molybdate orange, clean pastel tones with titanium dioxide and iridescent red-violet shades with nonleafing aluminum. — **National Aniline Div., Allied Chemical, New York.** **98G**

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*This extremely versatile material has contributed to the improvement of a variety of products as well as having helped make many new products possible. Oronite Polybutenes can pay you big dividends, too. Why not have your technical people evaluate these compounds for your present or future needs. A technical bulletin and Polybutene samples are available on request. Contact the Oronite office nearest you.*

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# POLYBUTENES

| Characteristics of Oronite Polybutenes | | Some applications |
|---|---|---|
| **Non-drying, tacky, viscous** — Grades from 50-20,000 SSU @ 210° F.<br>**Clear, colorless** — 1 or 1– on the Gardner color scale.<br>**Excellent stability** — Approximately one double bond per molecule; free from diene unsaturation. | in | automotive caulking compounds<br>soundproofing compounds<br>thermal insulation<br>industrial and household sealants<br>adhesives<br>special purpose greases and lubricants |
| **Compatible with a multitude of industrial chemicals, rubbers, and resins** — For example: soluble in benzene and ethyl ether; compatible with natural rubber and many styrene-butadiene copolymers; compatible with many phenol condensation products, polythylenes, and epoxy resins. | as | an extender for rubbers<br>a plasticizer for resins |
| **Outstanding electrical properties** — Dielectric strength at 80° C...35+ KV. Power factor at 100° C and 60 cps...0.01%.<br>**Impermeable to gases** — Composed of closely packed, branched-chain molecules. | as | an impregnant for paper insulation of electrical cable<br>a cable oil in compression cables<br>a dielectric for capacitors |
| **Outstanding hydrophobic properties** — Highly paraffinic; low polarity. | in | waterpoofing compounds<br>leather impregnants<br>coatings for porous materials such as cement and cinder block |
| **Leaves no ash or stain upon decomposition** — Decomposition occurs sharply near 500° F. | as | a lubricant in metal drawing processes |

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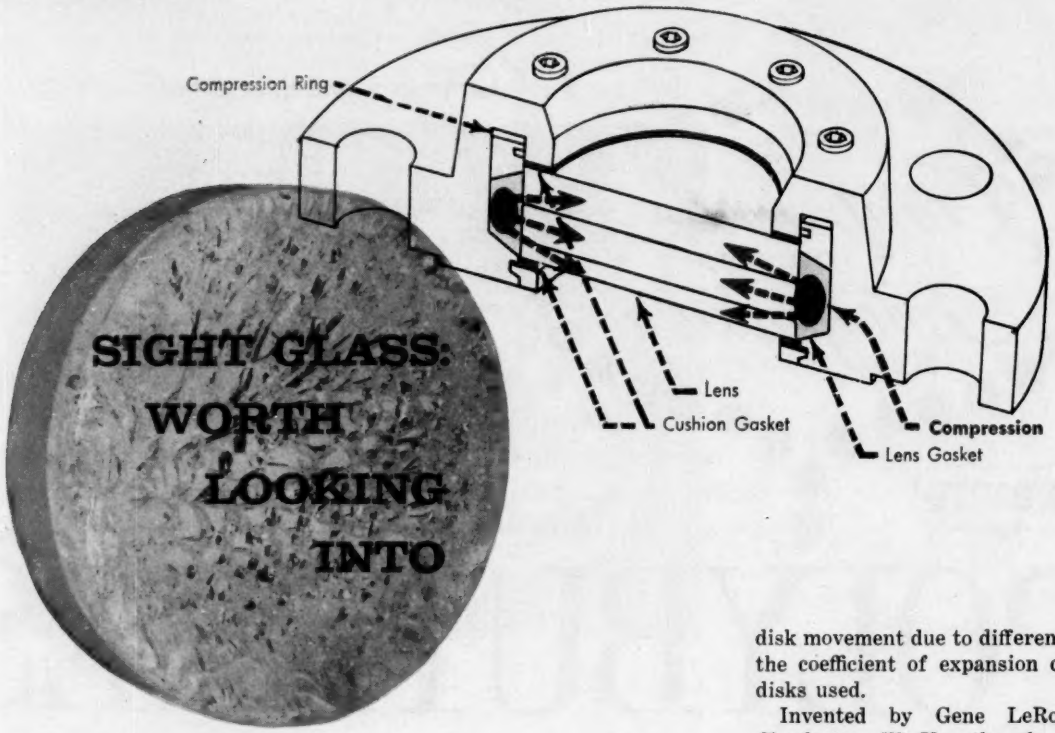
6906




- ***Compression on edge holds glass in mounting.***
- ***Multiple layers give extra safety factor.***
- ***It confines pressure up to flange rating.***
- ***Cover-disk protects glass from chemicals.***

The common sight glass—frequently the weakest link in a chain of pressurized vessels—is now available in a model that has as much strength as the flange that holds it.

The new glass has a unique mounting that eliminates stresses in the lens, reinforces the natural strength of the glass to the point where it can be used for all vapor and liquid service within the limits of the flange mounting—from full vacuum to the standard rated working pressure of the flange series.

In many conventional sight glasses, the lens is locked in place with a seal gasket that presses on the lens face. The new mounting avoids setting up stresses perpendicular to the face by placing the lens in a flange, surrounding it with a resilient gasket upon which rests a sloping compression ring.

When the compression ring is pressed down, the gasket firmly cushions the lens around its periphery. The compressive stress that is set up strengthens the lens against pressure or impact, perpendicular to its face.

▶ **Lens Construction**—Called Safelite, the lens consists of two outer tempered glass disks and one Pyrex-brand shielding disk (or any other specified glass material). All three are bonded together with a clear, high-temperature, chemically resistant interlayer.

Each of the main disks can hold the full rated flange pressure of the mounting, should the other break from accidental or natural causes. The shielding disk protects the pressure disks from chemical attack. Serving a double purpose, the interlayer prevents condensation between disks and absorbs any disk movement due to differences in the coefficient of expansion of the disks used.

Invented by Gene LeRoy of Charleston, W. Va., the glass was developed to its present state of reliability by PresSure Products Co., which obtained a patent license in 1957.

▶ **Safety Considerations** — Each unit is assembled and tested at the factory for pressure twice its normal operating capacity. Final installation on the pressure vessel can't affect the glass itself, since even uneven tightening of the mounting doesn't place the glass under undesirable stresses.

Since the design of the new glass was predicated on safety, the product underwent extensive testing before it was released for marketing.

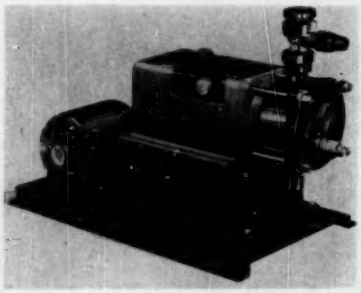
When subjected to 10 times normal operating pressure for an extended period of time, the lens was unaffected and only slight gasket leakage was reported. Also while under pressure, the glass was exposed to severe temperature changes and heavy steel balls were dropped onto the lens face.

Result: no rupture, blowout or other failure occurred. The impact of the steel balls did break the external lens, but the fractured glass remained on the face of the lens, held by the compressive force of the gasket. No leakage occurred.

Colored internal lens disks are available as shields against intense light; special nonbrowning

Front view of fractured lens. Secondary internal lens prevented complete rupture, maintained liquid seal.

glass can be used with radioactive materials. — **PresSure Products Co., Charleston, W. Va. 100A**



## Metering pump

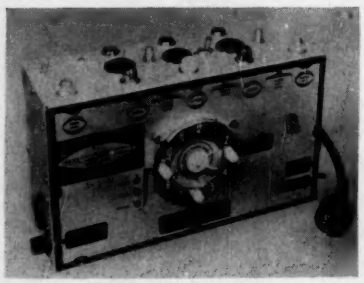
**Two corrosive liquids can now be metered at the same time.**

A low-capacity metering pump, able to handle up to 500 gpd. at 100 psi., comes equipped with interchangeable Tyril or Penton plastic heads to take a wide range of corrosive liquid flows.

The single-head model can meter up to 250 gpd., has a simple belt and pulley arrangement for scale-downs to 140, 80 or 40 gpd. Dual-head model can take 500 gpd. —either proportioning two different chemicals separately, or else handling twice the single-head capacity of the same liquid.

Stroke length can be adjusted over 10:1 range while the positive-displacement, diaghragm-action pump is operating. (On the dual-head model, stroke-length adjustment and indication for each head are separate.) Long diaphragm life is promised by short stroke length and slow stroking speeds, while the absence of stuffing boxes, shaft seals and packing glands eliminates leak worries.

The oil-enclosed, cam-drive mechanism features force-feed lubrication, double bearings, oil-level window and no cantilever loads. — **Wallace & Tiernan Inc., Belleville, N. J. 102A**



## Reaction automator

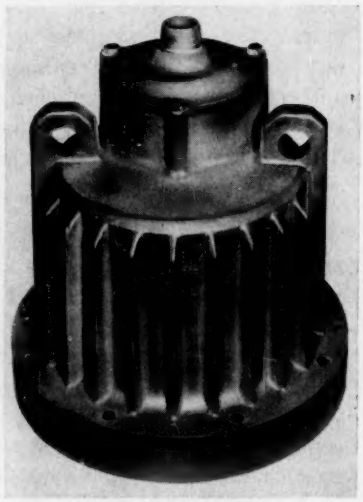
**Distillations, reactions can be carried out automatically.**

A new instrument "automates, programs, monitors and controls reactions and distillations of any size." Small (12 × 4 × 7 in.), with separate power and control circuits, the device permits highly individualized reaction control over preset limits of time, temperature, pressure, volume, position and motion.

Its versatility permits such operations as heating a number of reactants, adding reagent, raising the mixture to a higher controlled temperature to complete the reaction—all under specified time and pressure conditions. Furthermore, several reactions or distillations may be run simultaneously.

A built-in alarm system is activated by the interruption of the control circuit by any monitor; and corrective heaters, mixers, timers, and the like, may be programmed into the alarm system as well as into the central power circuit.—**Scientific Glass Apparatus Co., Bloomfield, N. J. 102B**

**For More Information about any item in this department, circle its code number on the Reader Service Postcard (Page 203)**

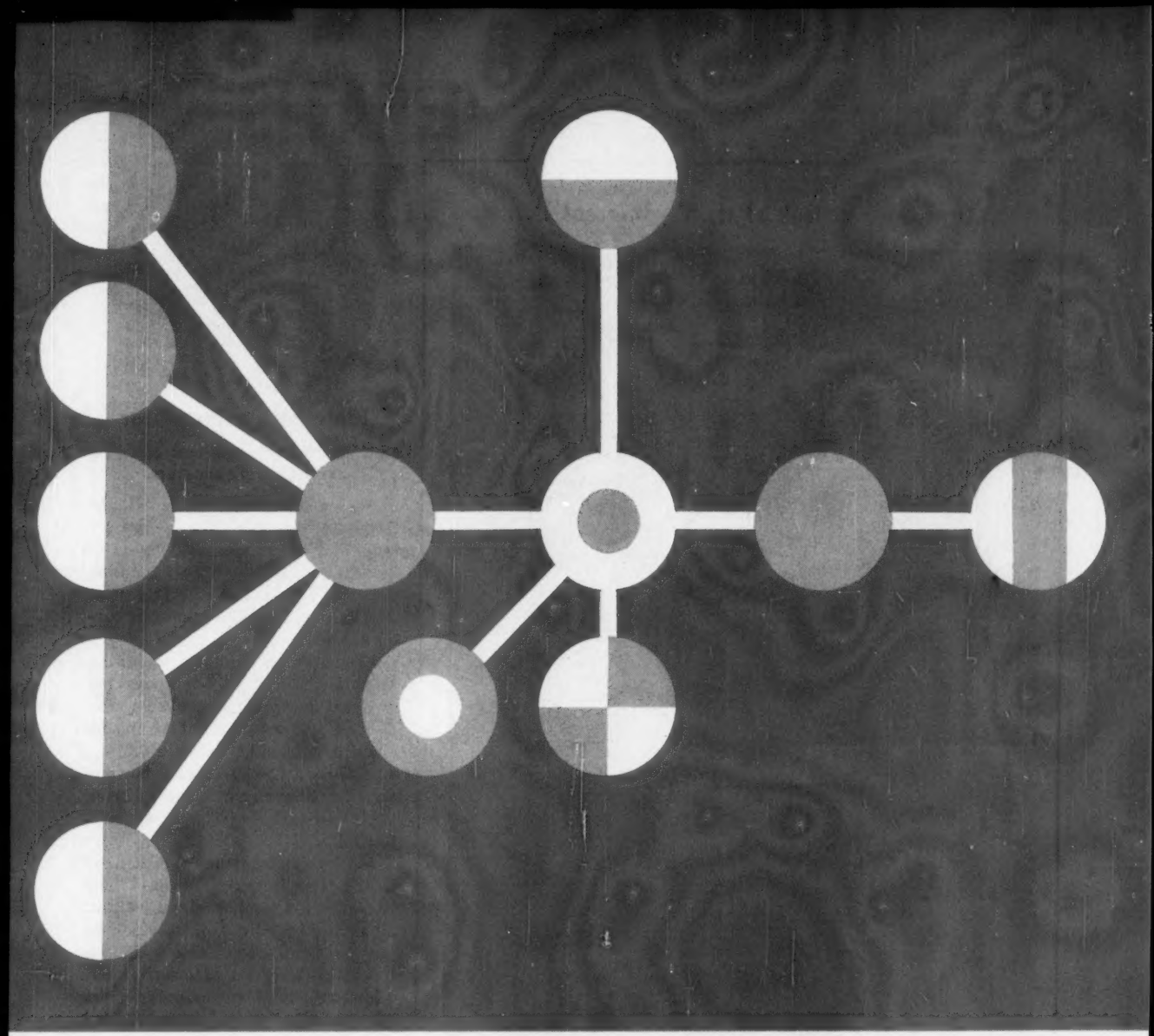


## Submersible motor

**Electric a.c. source is leak-, pressure- and corrosionproof.**

Designed for close coupling to centrifugal pumps under any depth of corrosive liquids, this line of submersible a.c. motors comes in capacities from ½ to 40 hp. (for polyphase power sources) and ¾ to 5 hp. (for single-phase connections).

The motors are oil-filled to protect against bearing wear, never need additional lubrication. Key to construction: a neoprene diaphragm with built-in O-ring and positive shaft seal, completely encircling the motor base, which disperses pressure differentials over the larger area by simple flex action. In 40 C. air, the motors are rated for 55 C. temperature rise during ½-hr. duty; in 40 C. liquids, same temperature rise—continuous duty.—**Reliance Electric & Engineering Co., Cleveland. 102C**



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DATA PROCESSING

FINAL CONTROL

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## BUYING A LOOP OR A NOOSE?

Why "strangle" process technology? Hagan solid-state, electronic controls are designed to meet rigid specifications of high reliability, simplicity, and repeatability . . . yet, they're flexible and adaptive enough to meet changing process needs.

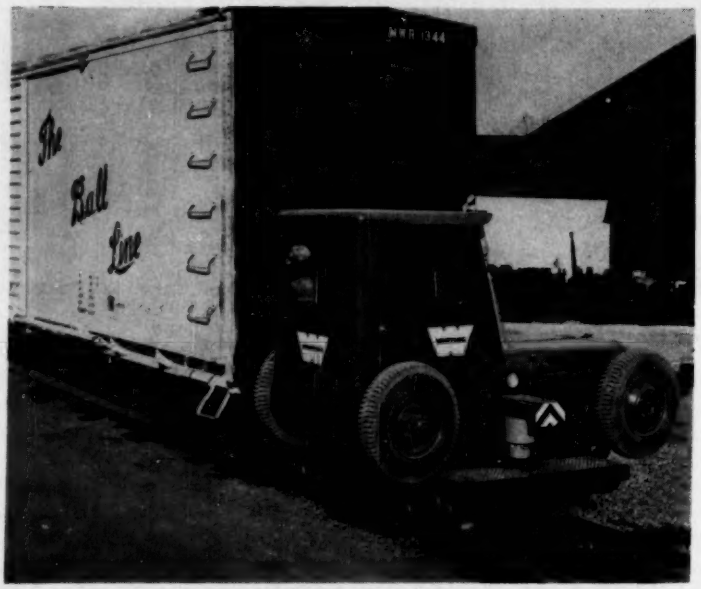
The core of Hagan's PowrMag electronic control loop is the controller. A high gain operational magnetic amplifier within the controller produces all control actions . . . proportional band, reset, rate . . . multiplication, addition and subtraction . . . through interchangeable resistive and capacitive components.

The Hagan electronic control system expands from this controller to other components that include all the hardware necessary for a simple or sophisticated control loop. From temperature, pressure and flow measuring devices to final control elements and data acquisition, each component has been engineered to meet high standards of reliability and accuracy.

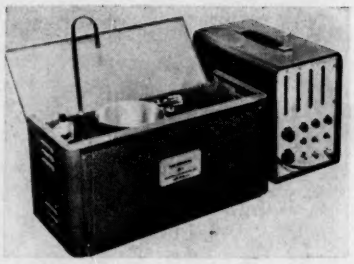
For information on Hagan PowrMag electronic process controls, write HAGAN CHEMICALS & CONTROLS, INC., Hagan Center, Pittsburgh 30, Pennsylvania, or telephone WAlnut 2-3737.

**HAGAN**

## Any way you look at it, it's different . . .




*It might be called a locomobile or an automotive—actually it's a trackmobile. On its rubber tires, it functions like a small truck for pulling dollies or plowing snow. With road wheels retracted, it rides the rails like a switch engine, can move a line of freight cars by either pushing or pulling. Chameleon-like, it can change roles in a matter of seconds. It can move a rail car anywhere, then drop its wheels and roll away. Its large tires allow driving over tracks even where it has to clear full rail height. And it has a special hydraulic coupler that permits transferring part of the weight of the freight car to its own wheels to give good traction in any weather.*—**Whiting Corp., Harvey, Ill.** **104A**



## Flow rate comparator

**New precision instrument can calibrate liquid flowmeters.**

Designed to calibrate liquid flowmeters within the range of 0-800 lb./hr., this laboratory-quality comparator is highly precise yet easy to operate. The unit checks orifice, rotameter and turbine-type flowmeters.

Based on a dynamic weighing principle, the inertia-compensated device electronically clocks the flow of a known weight of liquid. Accuracy is said to be ±0.25%; sensitivity, 0.0215%, and flowmeters don't have to be removed from their installations to be calibrated.

Mechanically, what's measured is the time it takes for fluid flow to balance a known added weight. A magnetic switch circuit senses the start and stop of this weighing cycle, triggers an external timer. Flow rate is then computed from the recorded time, known added weight, and a constant.

The basic unit requires an external electronic counter.—**Simmonds Precision Products, Tarrytown, N. Y.** **104B**

## Hot-water source

**Steam-water mixer turns out instant hot water.**

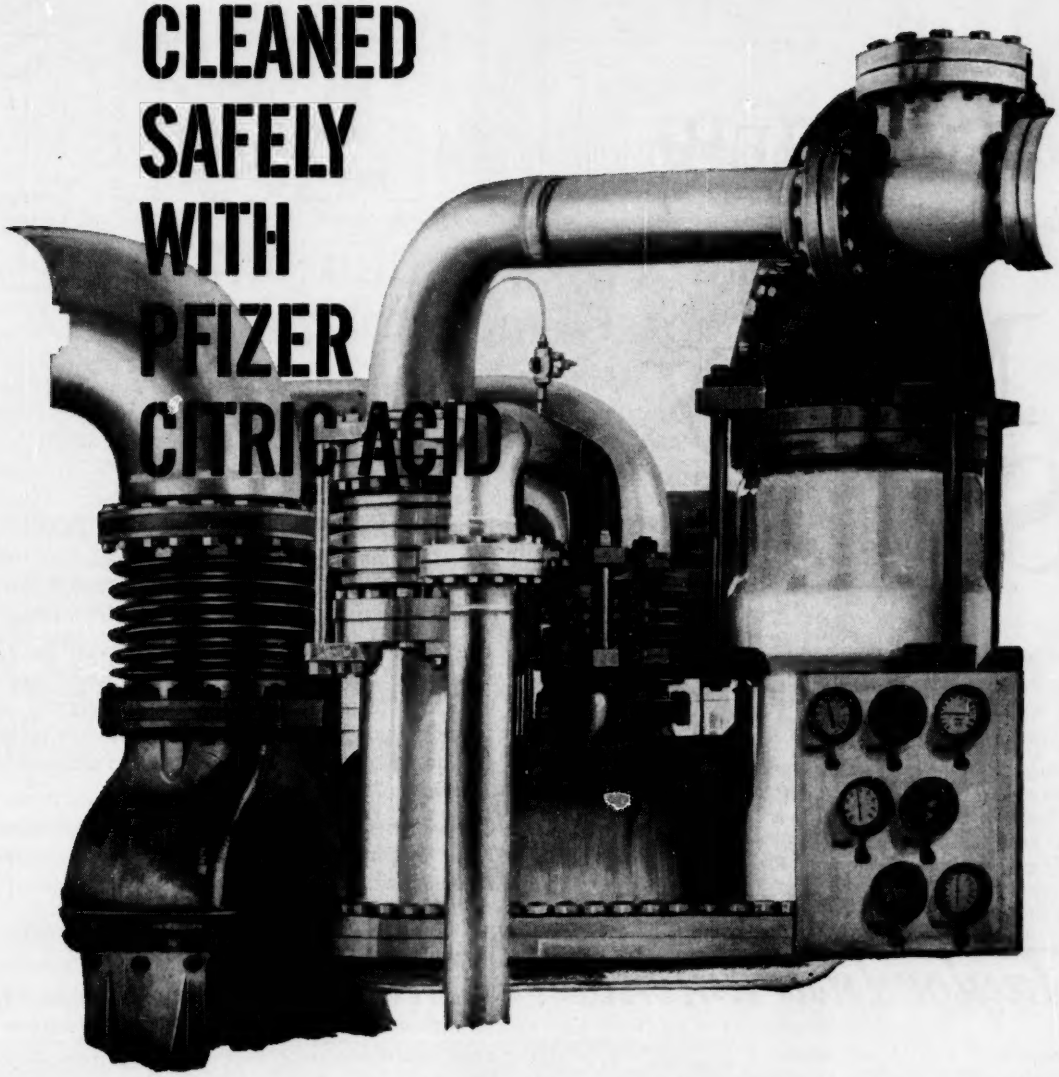
Hot water is yours—without tank or heater—through a new stainless steel, direct-diffusion steam and water mixer.

Available in two models (one 7½ in. long, weighing 6 lb.; the other

*More New Equipment News*

*(continued on page 176)*

# CLEANED SAFELY WITH PFIZER CITRIC ACID



STAINLESS STEEL BOILERS, HEAT EXCHANGERS, ATOMIC INSTALLATIONS, CHEMICAL PROCESSING EQUIPMENT CLEANED SAFELY, EFFICIENTLY WITH PFIZER CITRIC ACID

● Industry experience proves that citric acid eliminates chloride stress corrosion problems — provides effective descaling — permits easier, more efficient after-rinsing.

Discuss with your chemical cleaning service company these advantages of Pfizer Citric Acid in stainless steel cleaning solutions:

**1** Citric acid is highly efficient in removing imbedded metal and oxide films from stainless steel.

**2** Citric acid's excellent sequestering ability prevents reprecipitation of dissolved scale.

**3** Citric acid cleaning eliminates the problem of chloride stress corrosion.

**4** Citric acid can be effectively inhibited without losing its cleaning or sequestering ability.

**5** Citric acid is sold as a dry, 100% acid — meaning savings in storage and handling.

**6** Citric acid is water soluble, easy to handle, and non-toxic.

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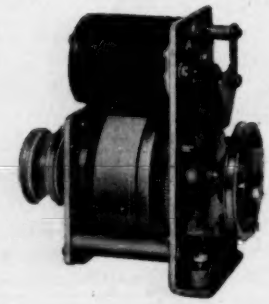
# ANOTHER Money Saving Feature OF *Taylor Instruments*



**SERVO POWER**

The powerful Servomatic motor in TRANSCOPE® Recorders and Transmitters, both pneumatic and electronic, is a plus feature that makes Taylor instrumentation more than ever your best buy.

The tremendous power of these servos not only overcomes friction and other problems associated with wear, it also means that the weakest signals, or the minutest changes in signal, are accurately registered and acted upon. It therefore assures unprecedented accuracy of recording and control.

Superior design, finest quality components and top-flight engineering combine to save you money in these areas:

- **You can maintain better product quality**—with accuracy of ½ of 1%, or ¼ of 1% if desired.
- **Your maintenance costs are reduced**—because rugged construction minimizes need for maintenance—and maintenance is simpler when required.
- **You can operate auxiliary equipment**—such as alarms, digital encoders and potentiometers because of the great reserve of power inherent in the servo motor.
- **You need a smaller inventory of parts**—and your operator training time is reduced.

* * *

*Ask your Taylor Field Engineer to show you how servo power can help you cut costs and obtain better control.*

*Taylor Instrument Companies*
*Rochester, N.Y., and Toronto, Ont.*

*Taylor Instruments*
**MEAN ACCURACY FIRST**

# DICALITE® TECHNICAL REPORT

DICALITE DEPARTMENT • GREAT LAKES CARBON CORPORATION • 612 SO. FLOWER ST., LOS ANGELES 17, CALIFORNIA

# Dicalite Filteraids Perform Vital Step in Uranium Oxide Production

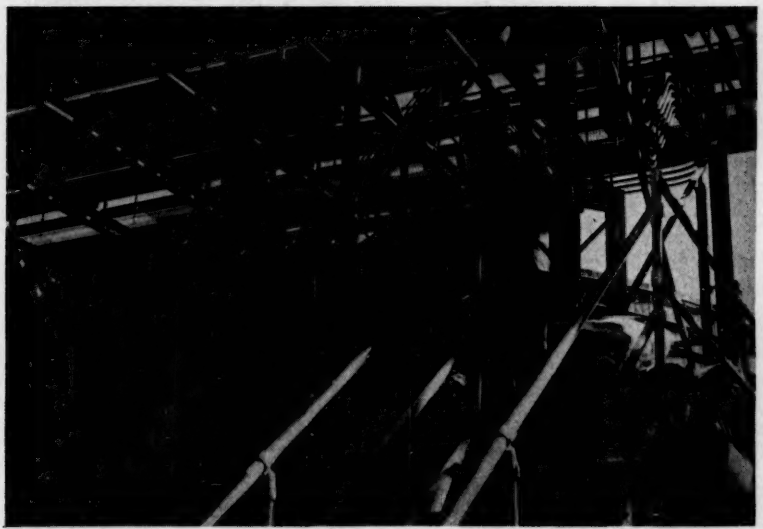
The filtration of uranium liquors for use in the atomic energy program is one of the newer applications of Dicalite. The important point, though, is the stage at which this filtration takes place, its difficulty and its critical nature.

Kermac Nuclear Fuels Corporation operates the largest type plant of its kind in the country at Grants, New Mexico. Contrary to popular belief, they do not make charges for atomic bombs. Instead, they produce yellow cake, which contains the uranium oxide ($U_3O_8$) that is sold under contract to the Atomic Energy Commission.

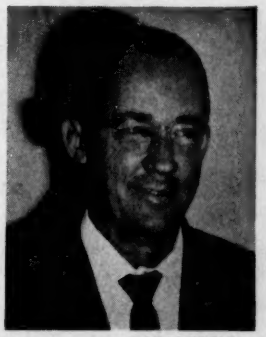
The process, briefly, is this: The ore, a type of sandstone, is crushed and leached with sulphuric acid. The leached ore is separated into sands and slimes by cyclones, with the sands being washed in rake classifiers and the slimes being washed in countercurrent thickeners. The washing solutions from both steps are combined, and this is where filtering with Dicalite Filteraids enters the process.

These solutions carry suspended solids, some of which are practically microscopic, requiring an extremely sharp filtration for thorough removal. This thorough removal is very necessary in the processing of uranium liquors in that the effluent from the filters must have a practically zero solids content for the following solvent extraction process to be most effective, and to provide required purity in the final product. Dicalite Filteraids have proven satisfactory in this critical operation, yielding a filtrate of desired clarity.

A Dicalite engineer is well fitted to advise with you on problems in filteraid filtration, either on everyday materials or unusual applications such as this.



*Dicalite Filteraid being poured into a mixing tank at Kermac Nuclear Fuels Corporation for the filtration of uranium liquors. From here the filteraid slurry is metered by a proportioning pump into the pregnant liquor going to stainless steel pressure-type filters, where the last traces of suspended solids are removed before the liquor goes into the solvent extraction phase.*



**William P. Belford**

**DICALITE'S "MAN ON THE SPOT"**

Before making specific filtration recommendations to Kermac, Bill Belford took samples of their uranium liquors to the Dicalite products laboratory at Walteria, California, for thorough preliminary tests. He also arranged to supply the Kermac laboratory with a Dicalite Bomb Filter, which is used to maintain a constant check on their filtration operations. He has worked closely with Kermac Nuclear Fuels ever since.

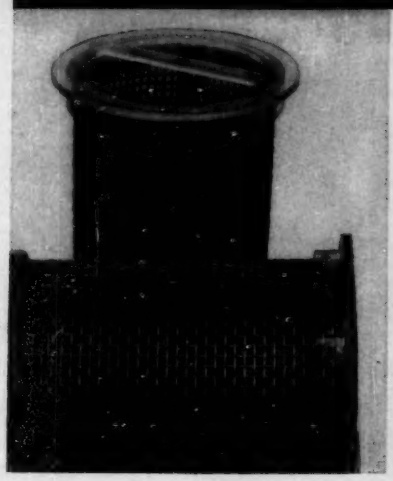
Before training as a Dicalite filtration engineer, Belford had an extensive background in chemical and mining engineering, with special emphasis on the technology of clays and related minerals. He studied at the University of Arizona, and was for 2 years with Gladding McBean, in laboratory control work. Deeply interested in the filtration of municipal water supply, Bill is a member of the American Water Works Association.

In addition to Kermac, Belford serves many other Dicalite customers in different industries throughout the Southwest.

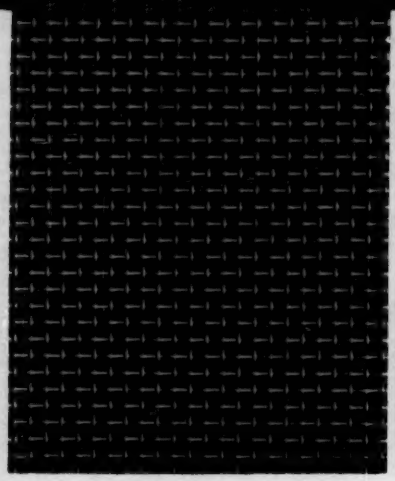
**TECHNICAL LITERATURE**

on Dicalite Filteraids is available on request. Bulletin B-14 discusses the principles and operating practices of filteraid filtration, and its applications in many industries. Write for your copy to Dicalite Dept., 612 So. Flower St., Los Angeles 17, Calif.

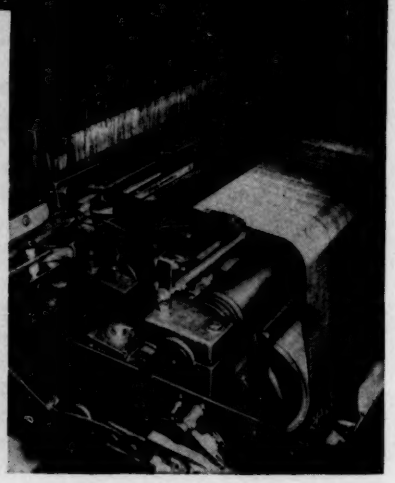
# Need Wire Cloth in Special Metals? call *Cambridge*



HASTELLOY C*



SILVER



TITANIUM

Working with unusual metals or alloys—as well as with standard metals and alloys—is almost an everyday occurrence at Cambridge. For instance, not too long ago, we developed the first practical method of weaving titanium into wire cloth—with mesh counts far higher than had been expected by the customer. Platinum, lead, stainless steel, or bronze—whatever the metal or alloy used, Cambridge has the experience and facilities to produce wire cloth in any size or quantities to the closest tolerances.

**If you require fabrications**—of any shape or size—Cambridge has the craftsmen and know-how to fill even the most rigid specifications. Or, we'll draw up prints for your approval. There's a wire cloth expert near you—ready to discuss your needs and show you how to get what you want economically and on time. He's your Cambridge Field Engineer... and his name is listed in the Yellow Pages under "Wire Cloth." Or, write for our illustrated, 120-page catalog.

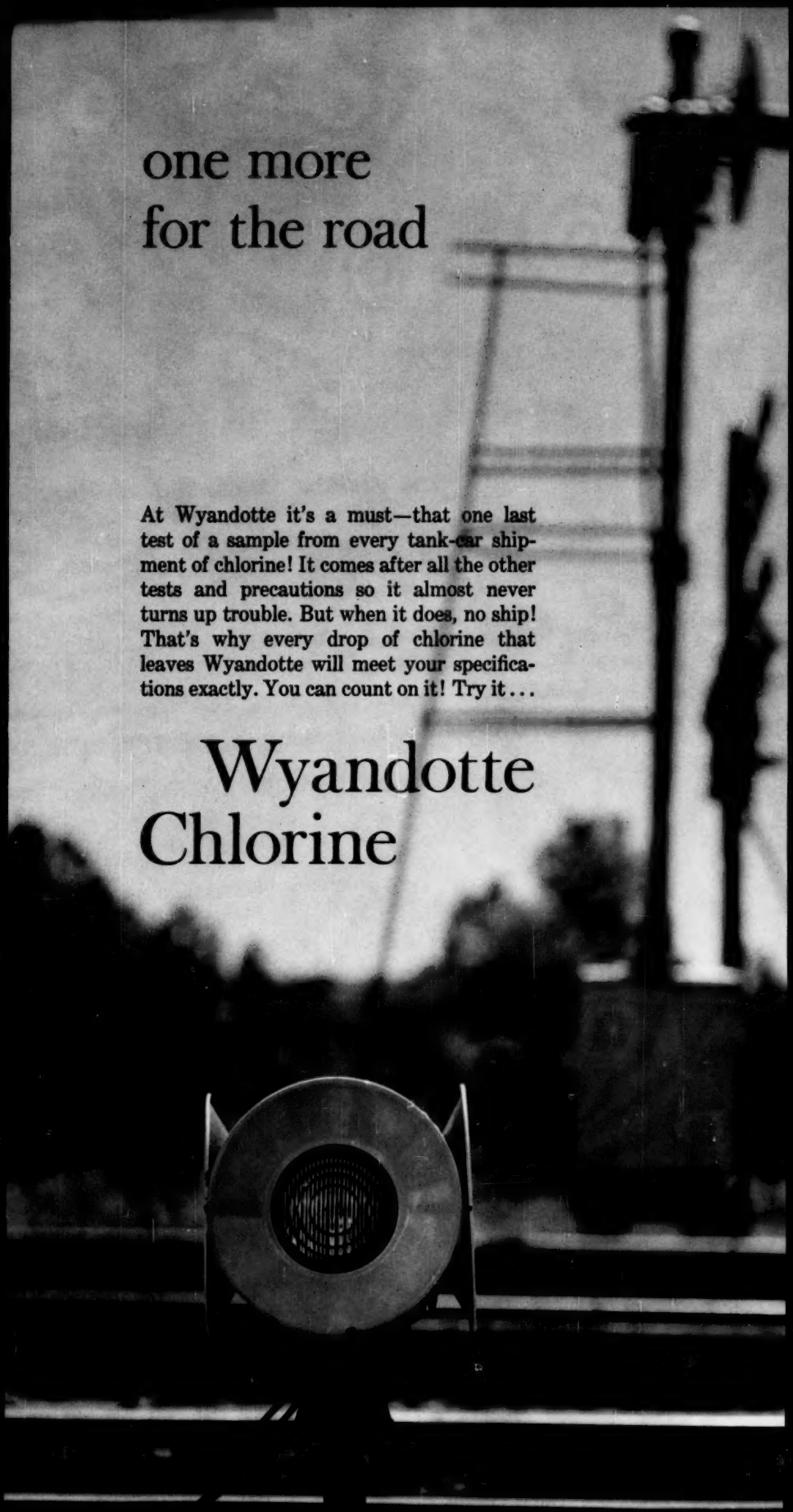
**Refer to our technical data sheets in CHEMICAL ENGINEERING CATALOG, Page 185**

**The Cambridge Wire Cloth Co.**

DEPARTMENT G • CAMBRIDGE 1, MARYLAND

*Manufacturers of Wire Cloth, Wire Cloth Fabrications, Metal-Mesh Conveyor Belts and Gripper® Metal-Mesh Slings.*

*Reg. T.M. of Union Carbide Co.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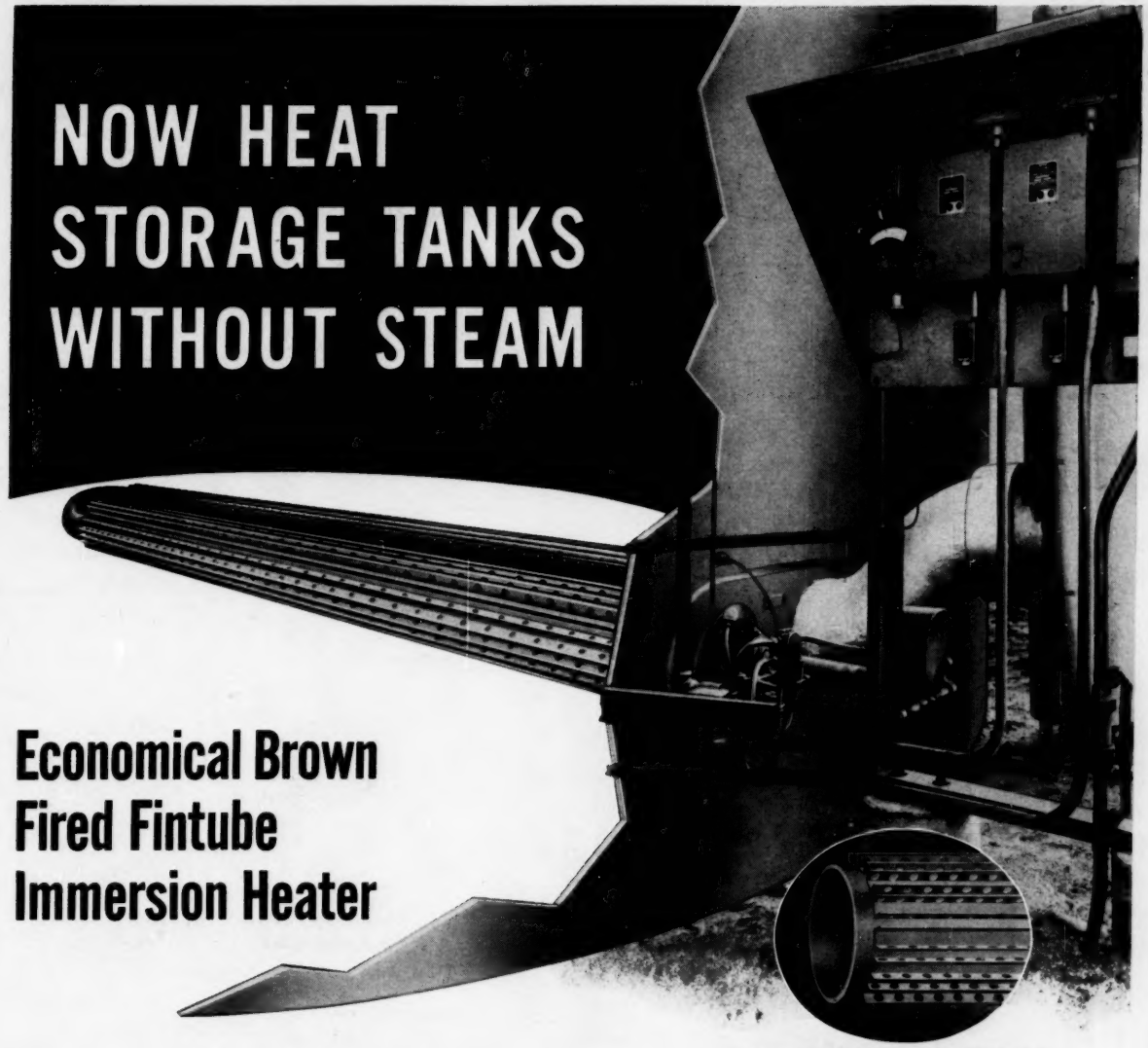
# NOW HEAT STORAGE TANKS WITHOUT STEAM



## Economical Brown Fired Fintube Immersion Heater

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Brown Fired Fintube Immersion Heaters heat asphalt, Bunker "C" oil, and other liquids in tanks for pumping, storage, blending, or loading . . . *without steam!* Low in initial cost and high in operating efficiency, fired immersion heating by Brown is the most economical method of tank heating. Not limited by steam temperatures, Brown Fintube Immersion Heaters can heat to any desirable temperature above those possible with steam. Two standard sizes, 10″ for 1,250,000 BTU/hr. and 8″ for 750,000 BTU/hr. Higher capacities by using multiple units. Gas or oil fired, with or without automatic control. Write for Bulletin 410, Brown Fintube Company, 300 Huron Street, Elyria, Ohio.

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Perforated Fins provide increased surface that lowers metal temperatures and increases efficiency. Perforations permit circulation around and through the fins, accelerating thermal currents. This improved circulation prevents stratification of material, minimizes fouling of fintube, and reduces sedimentation.

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Brown Fintube makes a complete line of steam and direct fired coils for all types of tanks. Write for Bulletin 300 and 410.

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HEAT TRANSFER PRODUCTS

**BROWN FINTUBE**

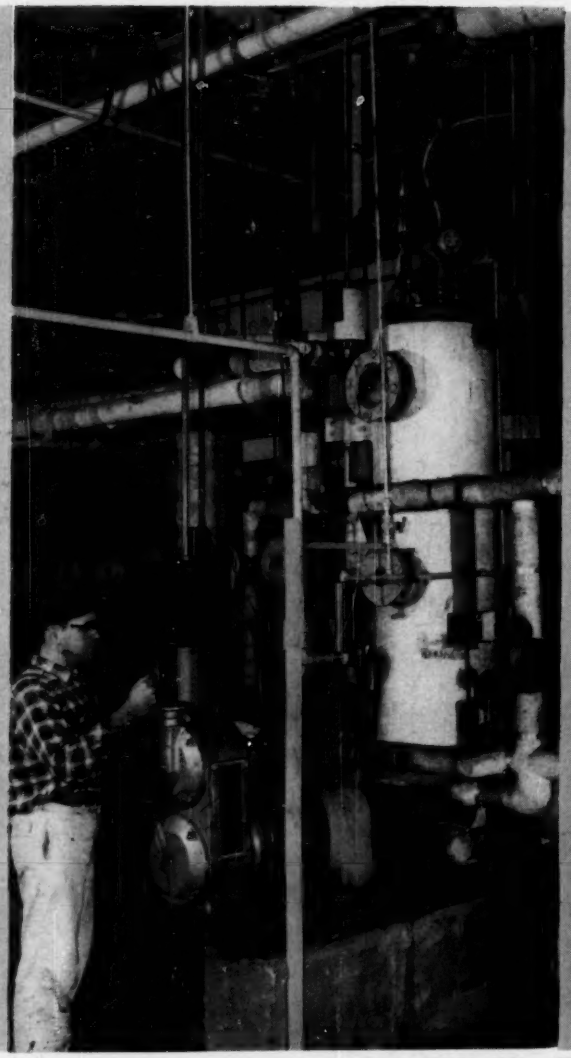
SYMBOL OF EFFICIENCY IN HEAT TRANSFER PRODUCTS

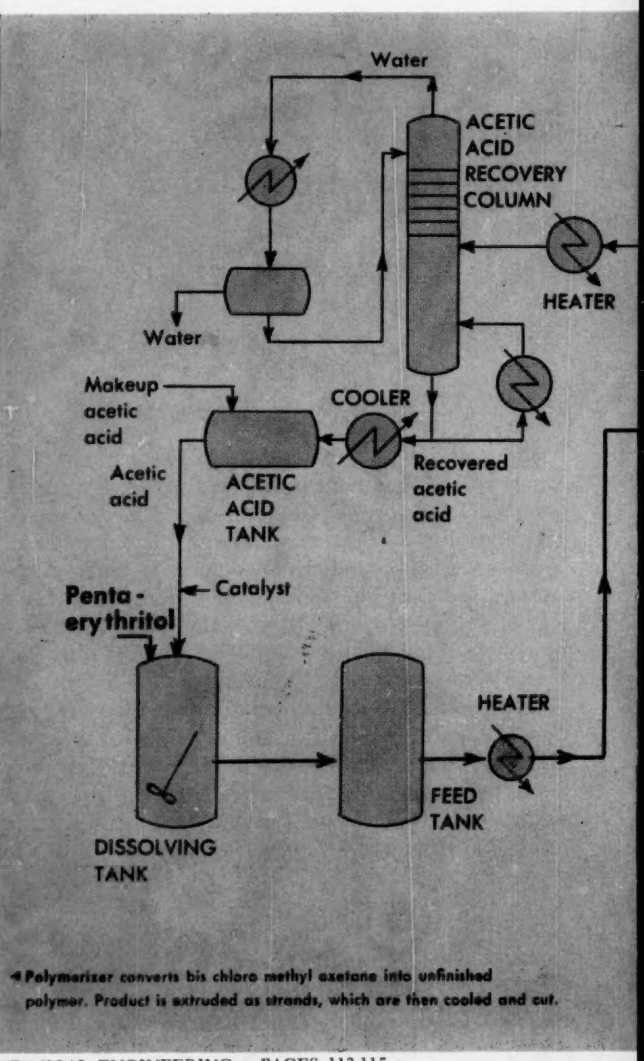
*Process Flowsheet*

# CHLORINATED POLYETHER

**Fully commercial plant climaxes Hercules Powder Co.'s market development for new thermoplastic that features blend of corrosion resistance, dimensional stability.**

Unfold flowsheet →






◄ Polymerizer converts bis chloro methyl oxetane into unfinished polymer. Product is extruded as strands, which are then cooled and cut.

N. P. CHOPEY

*Assistant Editor*

An intensive program of market development and semicommercial production reached full-scale fruition in the plastics field last summer, when Hercules Powder Co. started up a new, 2.4-million-lb./yr. plant to make chlorinated polyether molding compounds at Parlin, N. J.

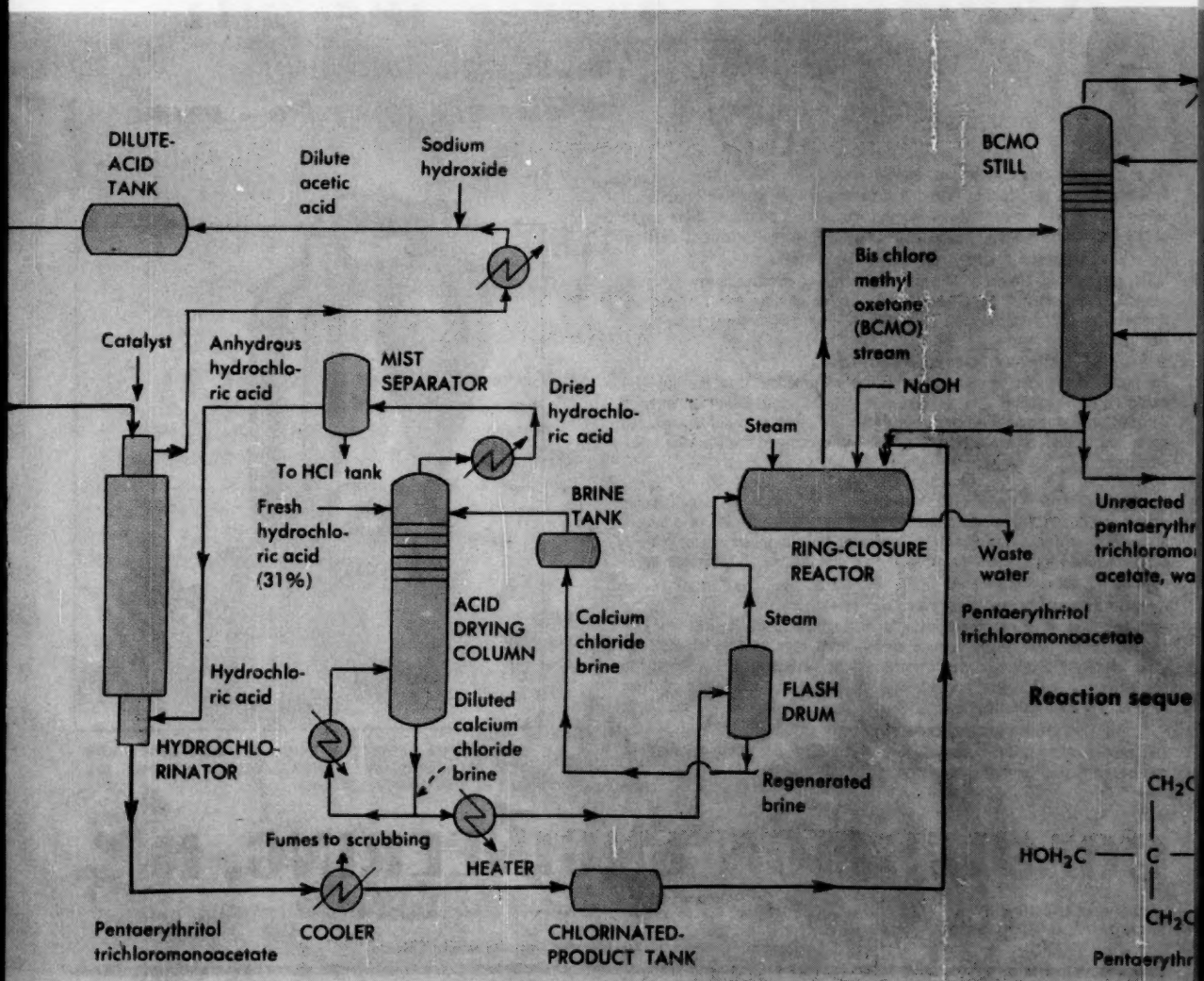
Sold under the tradename of Penton, the new compounds are polymers of bis chloro methyl oxetane. They feature a combination of corrosion resistance and high dimensional stability—they can be used in contact with virtually all chemical fluids except fluorine and a few full-strength acids, in most cases at continuous temperatures of 250-275 F. And they have good fabricability: solid-Penton equipment, as well as equipment coated or lined with this thermoplastic, is commercially available and has won acceptance in applications such as pipe and fittings, valves, tanks, pumps and meter parts.

Selling price—currently $2.50/lb.—will keep Penton in the category of a high-quality specialty resin. Hercules declares that the product offers advantages in performance, and in some cases in price, over metals for many uses.

▶**Chemistry**—Penton provides Hercules with an attractive outlet for pentaerythritol, a polyhydric alcohol that is made by the firm at Louisiana, Mo., and that also finds an outlet in production of alkyd resins for paints.

Over-all procedure for making the plastic starts with a three-step operation for synthesizing the monomer from pentaerythritol. This is followed by polymerization, separation of unreacted monomer and finishing the product Penton for sales.

First, the pentaerythritol is treated with



acetic acid. Resulting tetra-acetate is hydrochlorinated to give a high yield of the trichloromonoacetate, and latter material undergoes a ring-closure reaction to produce bis chloro methyl oxetane (BCMO), which constitutes the monomer (see reactions, below).

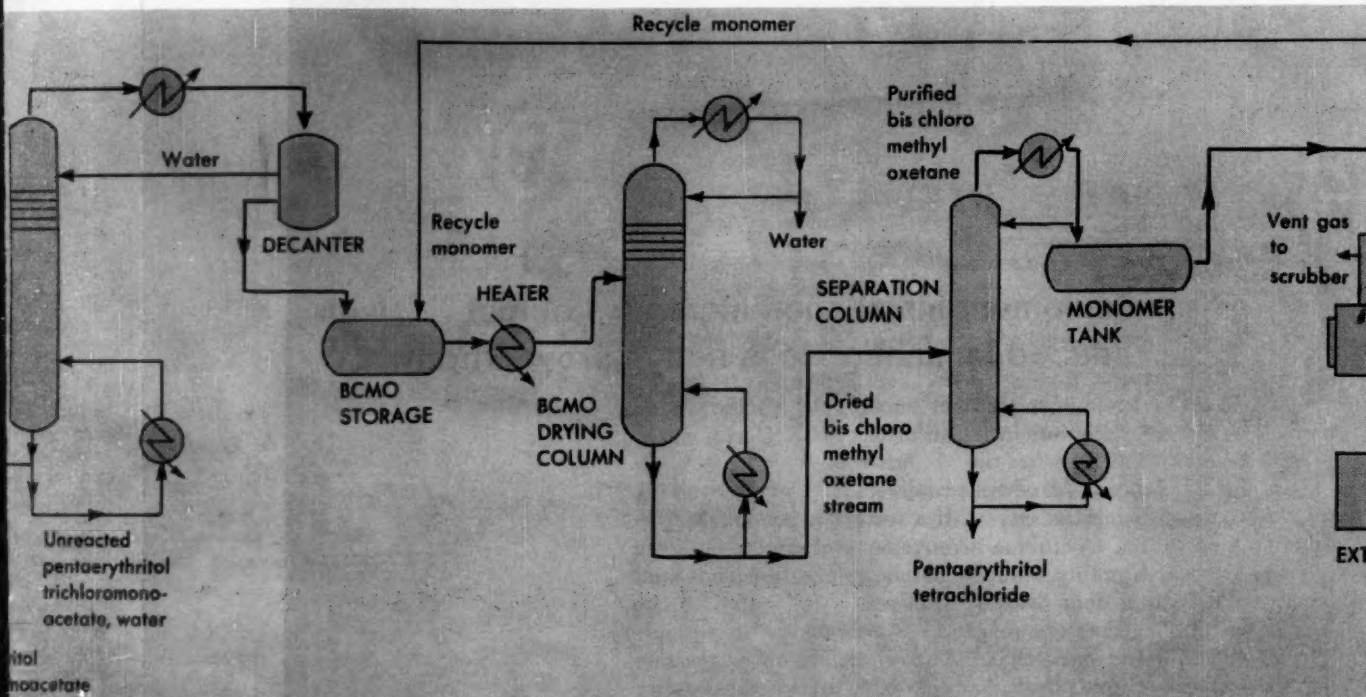
Monomer is polymerized, and unreacted BCMO is separated and recovered for recycle. The polymer is blended with coloring agents, then finished for sale as pellets or powder.

▶ **Following the Flow**—Pentaerythritol is combined stoichiometrically with glacial acetic acid, together with an undisclosed catalyst, in a small dissolving tank at slightly above ambient temperature. Partially reacted mixture is heated, then enters the top of a specially designed hydrochlorinator with a second catalyst. The reaction with acetic acid doesn't reach completion until after the hydrochlorination has gotten under way.

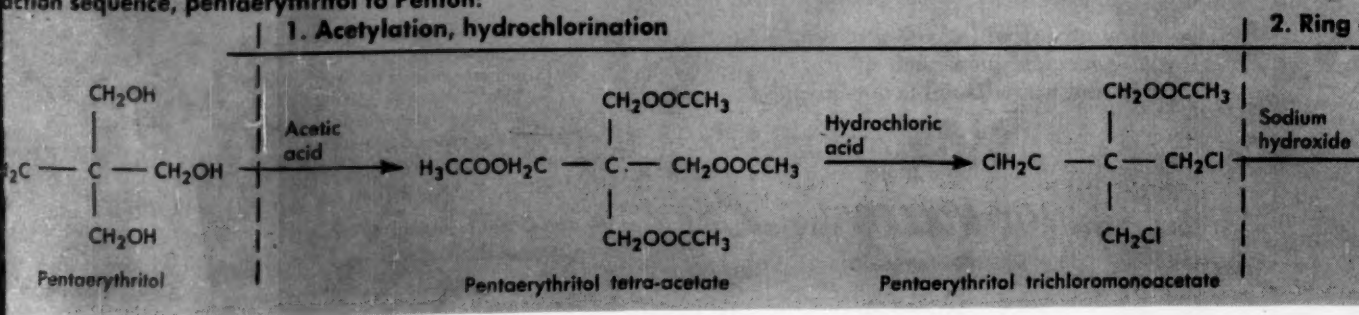
Anhydrous hydrochloric acid feed for the hydrochlorinator is prepared by contacting 31% acid with calcium chloride brine in a tray column 24 ft. high. Acid leaves overhead, is cooled and demisted, then enters the bottom of the hydrochlorinator; diluted brine leaves the tray column at about 300 F. and is then regenerated by flashing in a drum.

▶ **Hydrochlorinate, Close Ring**—The hydrochlorinator is a vertical, jacketed liquid-gas contactor about 50 ft. high. Reaction pressure is up to 25 psig., and the hydrochlorination product, pentaerythritol trichloromonoacetate, leaves the bottom at about 320 F. Acetic acid distills out and leaves overhead, together with some water. This stream is caustic-treated to assure that any chloride ion present is bound; then the stream is heated and goes to a tray column where acid is recovered as bottoms.

The trichloromonoacetate is cooled after leav-




**action sequence, pentaerythritol to Penton:**



ing the hydrochlorinator. Next, it is combined with sodium hydroxide in a ring-closure reactor—a horizontal, tanklike vessel that also serves to steam-distill the closed-ring product.

Reaction product, bis chloro methyl oxetane, leaves in an overhead stream under vacuum at 160-212 F. It is then separated in three distillation steps to prepare it for polymerization.

► **Separate**—The first distillation is carried out under vacuum in a tray column 45 ft. high. BCMO stock and some water come off the top at about 160 F. and go to a decanter. Most of the water that was introduced with the column feed leaves as bottoms, together with unreacted trichloromonoacetate, and recycles to ring-closure.

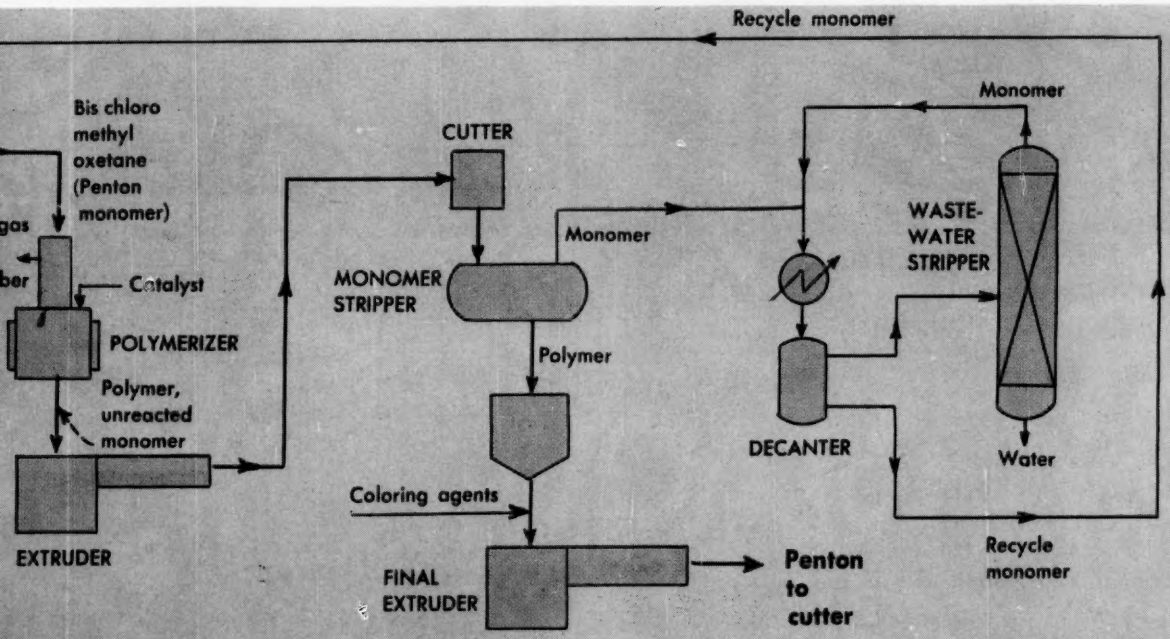
BCMO stock from the decanter is heated and goes to a second distillation column, a tray column that functions as a dryer. Water leaves overhead; the BCMO stream leaves the bottom at about 355 F.

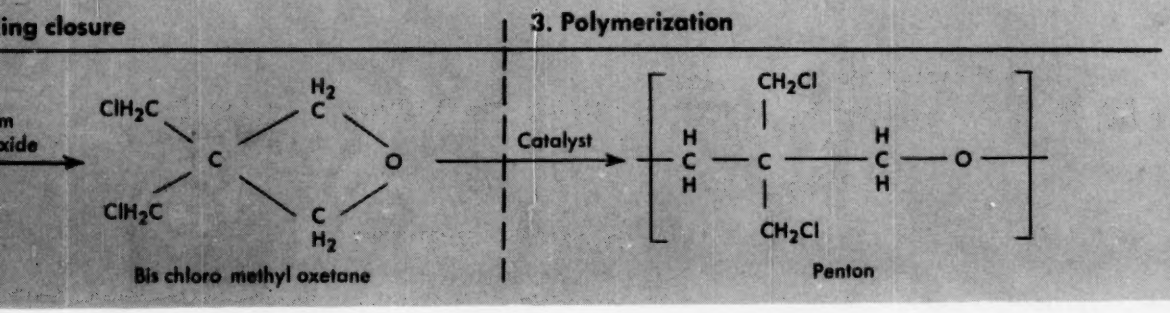
The third distillation column serves to remove byproduct tetrachloride as bottoms. It is 70 ft. high, operates with a temperature difference of about 85 F. between top and bottom.

► **Polymerize**—Polymerization of the BCMO takes place in a reactor specially designed to give high yield with a single pass. It operates above 390 F., uses a catalyst of the Lewis acid (electron acceptor) type.

A mixture of polymer and unreacted monomer leaves the reactor, goes through extrusion and cutting steps to a horizontal, tank-type vessel that strips the monomer. Monomer leaves overhead, is separated from water introduced during formation and handling of the polymer, and recycles to the distillation system.

Polymer is combined with coloring agents, then is ready for final extrusion and processing to yield finished Penton in the form of pellets or powder.



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Men in white clean and sterilize Adsco Expansion Joints with steam and detergents, dry, and hermetically seal them in polyethylene bags. At an Air Force Titan missile base, system contamination is less than 25 parts per million, with no particle larger than 150 microns.

Cleanliness of this magnitude reveals the slightest imperfection. The construction of these expansion joints which glisten like diamonds is revealed as not just good, but perfect; one slip could bring disaster.

When special designs and/or services with quality workmanship and dependability are required... call on Adsco.

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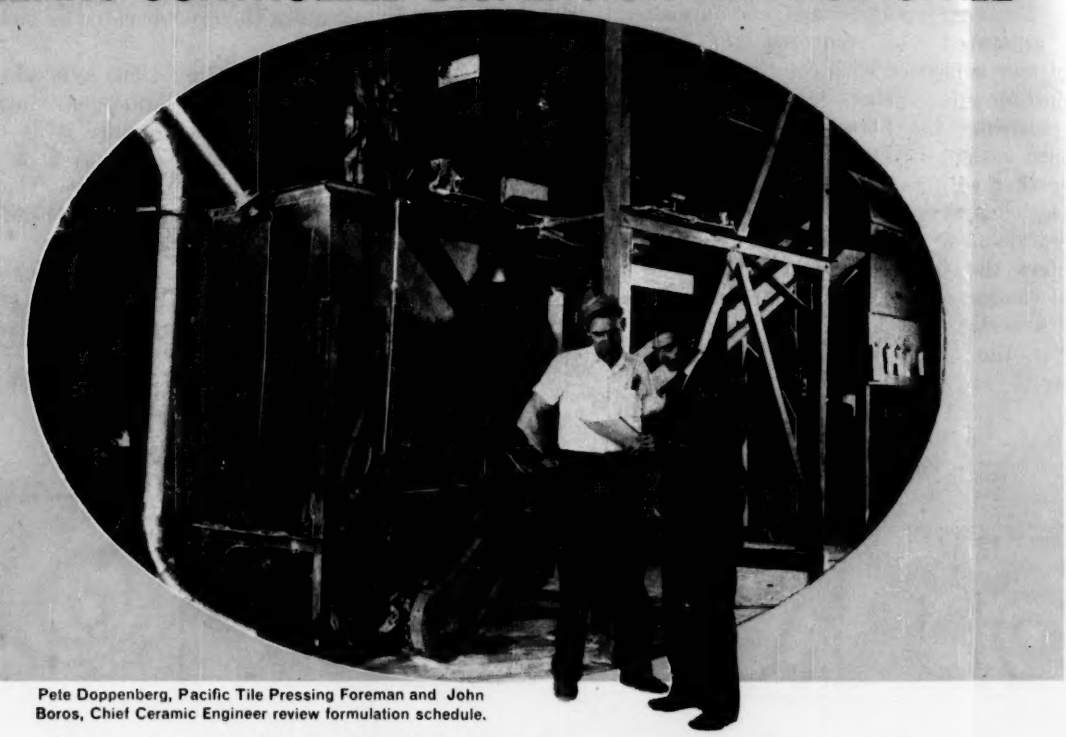
1060-R

# MIX-MULLER®

## IEANS CONTROLLED DISPERSION AT PACIFIC TILE



Pete Doppenberg, Pacific Tile Pressing Foreman and John Boros, Chief Ceramic Engineer review formulation schedule.

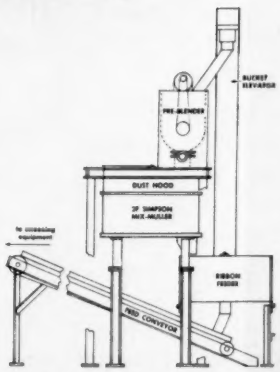
### New equipment installation increases output . . . with reduced lamination loss and improved body

sed tile output alone was not enough for Pacific Tile & n Company, Paramount, California. John Boros, Chief Engineer wanted *better* tile . . . *faster*.

new 2F Simpson Mix-Muller delivers 50% greater mixing and excellent plasticity with a *reduction* in moisture re- nts per batch. A unique arrangement of equipment (see has considerably reduced batch preparation time and ller's bottom door discharge delivers a full batch to the pper in less than one minute.

Tile wanted *more* than a mixer. *Controlled Dispersion* -Muller's unique physical adaptability to ceramic systems, d with National Engineering Company's know-how helped achieve their goal of increased quality . . . *in quantity*.

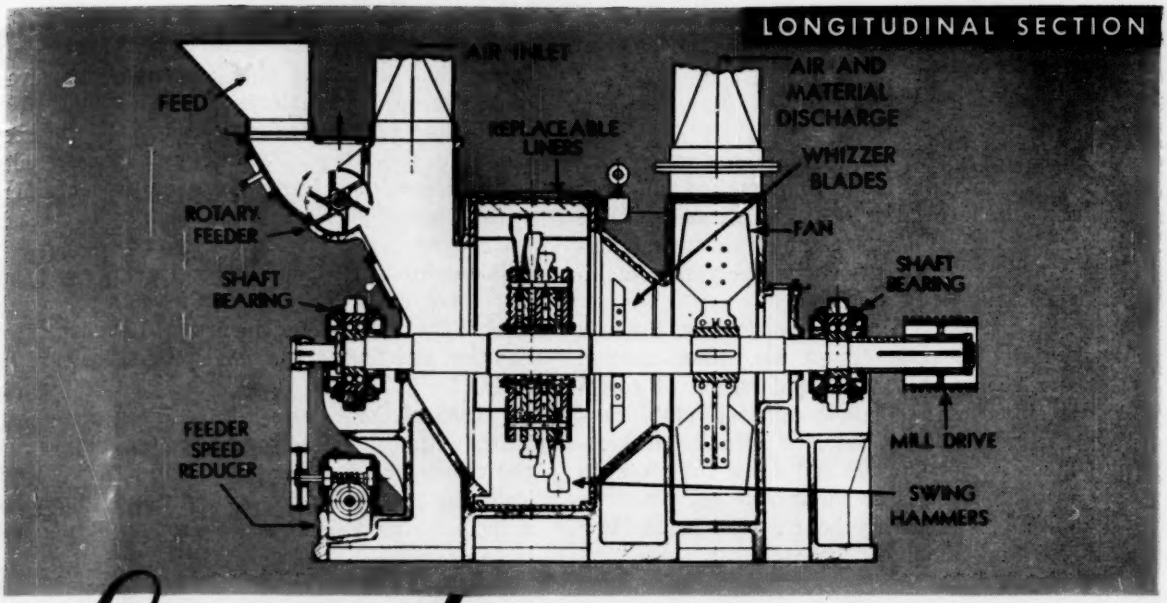
If *you* mix, it will pay you to remember that the *controlled* dispersion of dry/solid, solid/solid and wetted/solid is our *business*.




**Efficient layout** of preparation equipment at Pacific Tile permits near-continuous operation. Ribbon mixer conserves valuable mulling time by preblending dry mix. Batch can be charged to muller within one minute of muller discharge.

**SIMPSON MIX-MULLER® DIVISION**

**National Engineering Company**
636 Machinery Hall Bldg. • Chicago, Illinois




# Raymond's RUGGED IMP MILL

## THE MULTI-PURPOSE GRINDING UNIT

**GRINDING • BLENDING • SEPARATING • CONVEYING • DRYING**

**✳ DESIGNED FOR FINE GRINDING**

The Imp Mill is particularly intended for medium fine and fine grinding of softer non-metallic minerals and many manufactured products. Wide usage of the Imp Mill is made in a great many fields where pulverizing is desired.

**✳ VERSATILITY OF APPLICATION**

Mills are built in a variety of types and sizes to produce many different capacity requirements. They have a wide degree of adjustment of product fineness, ranging from about 20 mesh to 325 mesh, depending upon material handled.

**✳ NEED OF CLASSIFIER**

For higher finenesses or more uniform finished products than the Imp Mill would normally produce, an air classifier may be used. Either an integral Whizzer Separator or a Raymond Mechanical Air Separator could be installed according to the particular type of operation needed and the material to be processed.

**✳ FLASH DRYING**

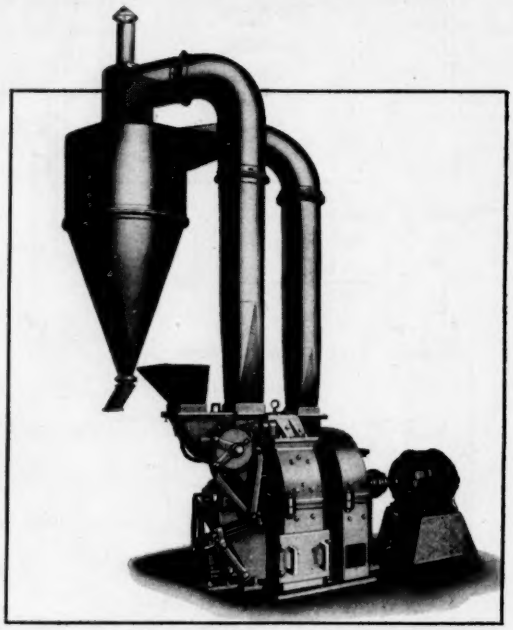
The basic design of the Imp Mill readily adapts itself to the simultaneous drying and pulverizing of materials. The Mill utilizes heated air or products of combustion for removing surface moisture and, in special cases, chemically combined water from materials during grinding. In all instances air is used as the conveying medium.

**✳ FLEXIBLE IN INSTALLATION**

Each Mill System is a compact installation, engineered to fit most any plan or layout. The floor space is held to minimum requirements of Mill and Drive Motor. Piping variations permit cyclone collector, within limits, to discharge material where needed. Systems are completely enclosed from feed hopper to finish bin.

**✳ DUSTLESS OPERATION**

The excess air is diverted to a secondary collector or, where permissible, can be exhausted to the atmosphere.



FOR FURTHER DETAILS ON THIS AUTOMATIC UNIT WRITE FOR RAYMOND IMP MILL CATALOG NUMBER 87E

# COMBUSTION ENGINEERING, INC.

## Raymond Division

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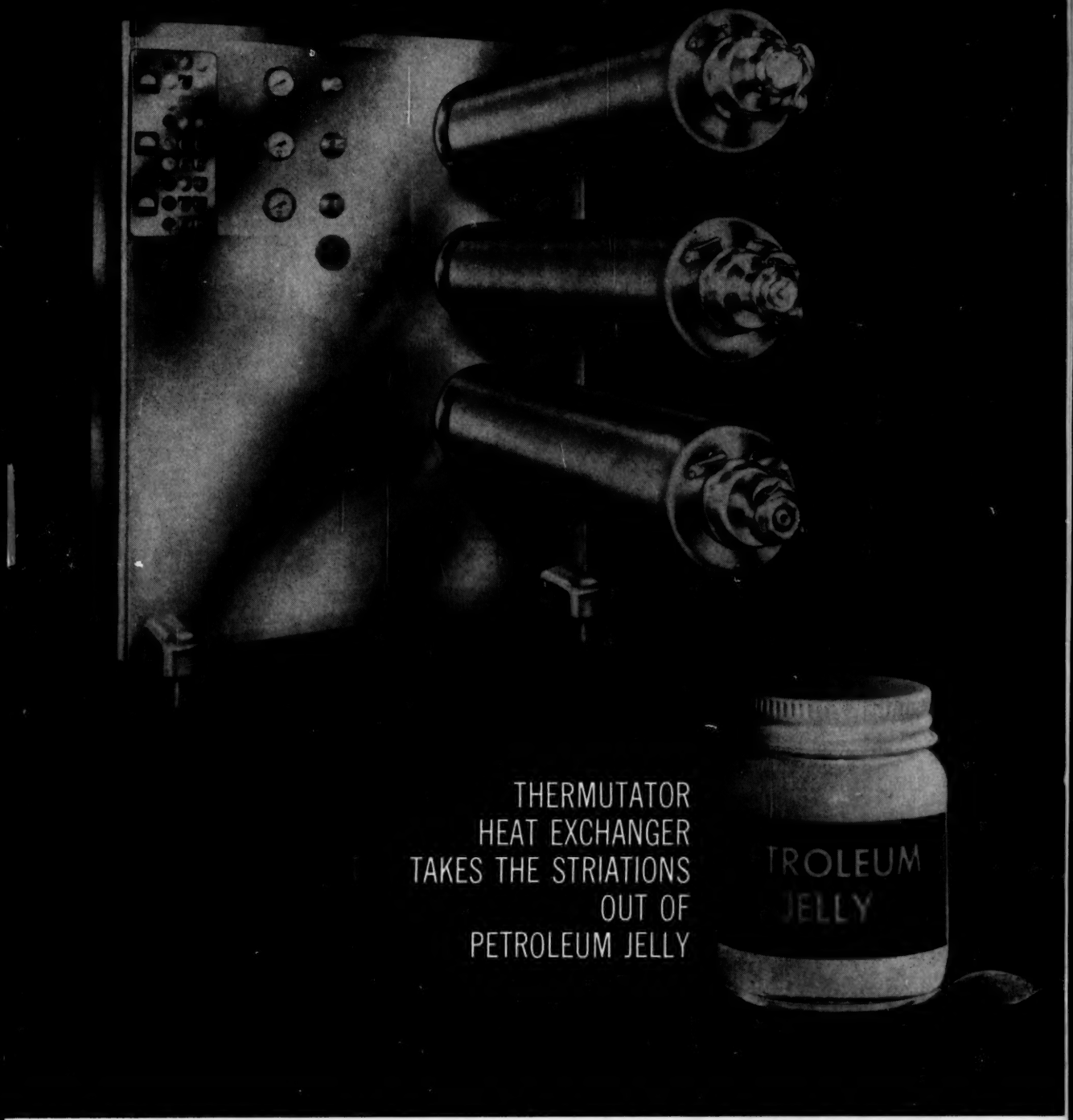


THERMUTATOR
HEAT EXCHANGER
TAKES THE STRIATIONS
OUT OF
PETROLEUM JELLY

# Cherry-Burrell Cures Those Jelly Row Blues

Product appearance can make or muff a sale as a large manufacturer of petroleum jelly discovered. His product lay in unappealing rows or layers of different textured jelly. He asked Cherry-Burrell if they could give his product more of a *togetherness* look, solve his Jelly Row Blues.

After studying his manufacturing process and running laboratory tests on the product, Cherry-Burrell engineers found the trouble. The manufacturer's previous equipment cooled too slowly and produced striations in the jar.

The engineers recommended a Cherry-Burrell Thermutator. Now the manufacturer has complete control over product temperature. And the Thermutator blades texturize the product, give it a smooth, uniform appearance. Sales picked up. And now the manufacturer whistles a happy tune. Why not? His petroleum jelly is a popular first choice everywhere.

Highly trained technicians will test your product without obligation in a Cherry-Burrell laboratory. They will show you how Cherry-Burrell food processing equipment can help you improve your operation and profit position. Your specialists are invited to participate in the testing. Call or write Cherry-Burrell today.

***Case history on request.*

***Equipment for homogenizing, heating, cooling, flavorizing, storing, separating, freezing, mixing, packaging and conveying. Write for your free catalog.***

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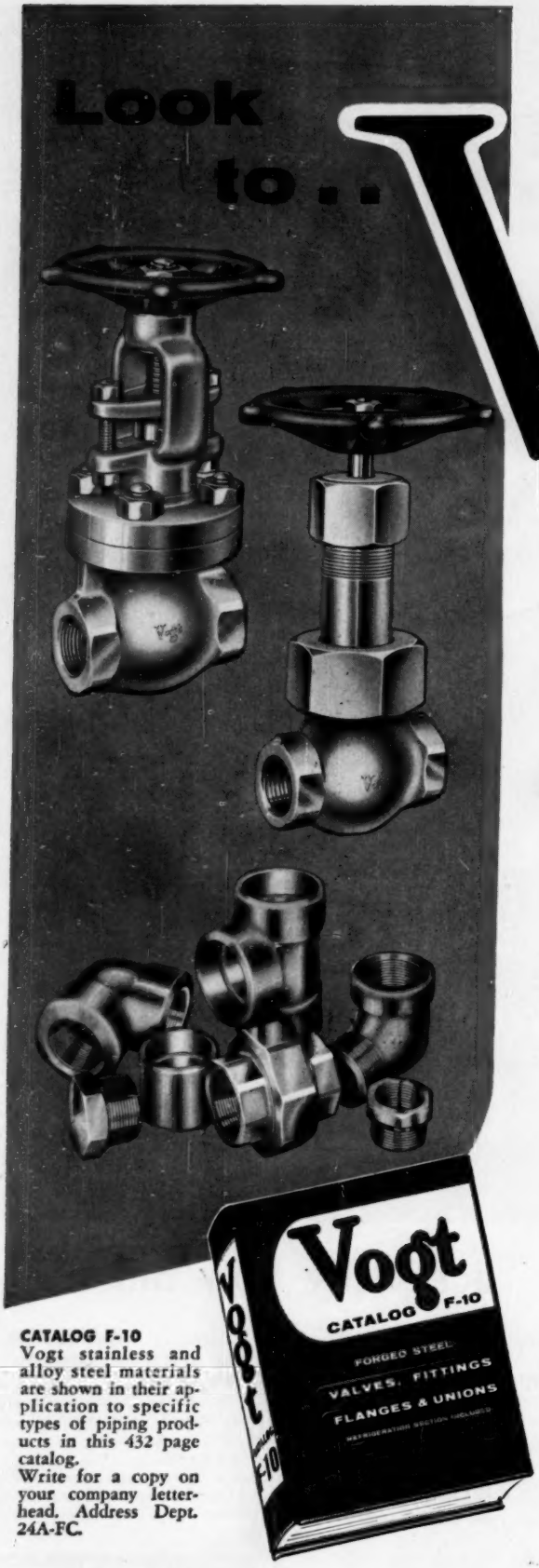


# Vogt

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# 10th Semiannual Inventory of New Processes and Technology

In this special eight-page section, you will find more than 160 significant process and technology developments in the chemical process industries for the period March through October 1960.

Tenth in *Chemical Engineering's* long series of such reports, this is the first one to be issued under a new schedule calling for tabulations every six months. Our similar tabulation of new plants and facilities has also gone on an accelerated six-month schedule which alternates with the present tabulation so that one or the other appears at three-month intervals. The first semiannual tabulation of new plants and facilities will be found in the October 17th issue.

Listings have been compiled from a number of sources and screened carefully to put you on top of the latest developments. They cover only projects that have been made public and that have reached an advanced stage of development.

## Fine Organic Chemicals

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Dimethyl sulfoxide | Sulfonation, oxidation | Crown Zellerbach Corp. Bogalusa, La. | Black liquor is sulfonated to form dimethylsulfide and methyl mercaptan. DMS is converted to DMSO by liquid phase oxidation using a nitrogen oxide catalyst. Replaces process that used sodium sulfide in the form of smelt from kraft mill chemical recovery furnace. | Plant is on stream. |
| Insecticide, microbial | Fermentation.... | Bioferm Corp. Waseo, Calif. | Process produces a microorganism spore that induces disease in certain insects, yet is not toxic to plants or animals. Incubated culture moves step-wise to 12,000 gal. tank from test tube. Spores are separated in a filter press; filter cake dried in a vacuum tray dryer; then ground, blended, mixed with clay. | Current production is 2 tons/day of concentrate. |
| Monosodium glutamate | Synthesis..... | Ajinomoto Japan | Petrochemical-based acrylonitrile is converted to aldehyde by reaction with oxygen in a solvent using an unnamed catalyst. The aldehyde is reacted with methane and ammonia to produce a compound that can be hydrolyzed to racemic glutamic acid. Glutamic is extracted to produce MSG. | $11-million, 300-ton/mo. plant to start up early in 1962. |
| Polio vaccine..... | Nine-step..... | Merck, Sharp & Dohme Various | Nine-step process includes virus growth, filtration, nucleic acid precipitation, enzymatic digestion, salt fractionation, ultracentrifugation, clarification, analysis and standardization. | Only two doses needed for full protection. |
| Sorbitol..... | Hydrogenation... | Merck & Co. Danville, Pa. | Raney nickel catalyst promotes hydrogenation of dextrose to sorbitol. Reaction takes 3 hr. to complete at 1,000 psi. 50% solution is concentrated to 70% before sale. | Commercial. |
| Starch phosphates | Esterification.... | American Maize-Products Co. Hammond, Ind. | Process makes starch phosphate esters from a mixture of sodium dihydrogen phosphate and disodium monohydrogen phosphate buffered to pH 7 and reacted with starch. | American Maize plans 60,000-lb./wk. plant. Licensed from International Minerals & Chemical Corp. |
| Tetramethyl lead. | Undisclosed..... | Houston Chemical Corp. Houston, Texas | Process is undisclosed. Houston Chemical Co., subsidiary of Chatham-Reading which in turn was formed by Chatham Chemical and Philadelphia-Reading Corp., will operate plant. | Plant now under construction. Du Pont and Ethyl Corp. also making TML. |
| Waxes, decolorized | Thermofor continuous percolator | Western Petrochemical Corp. Chanute, Kan. | Brown, deoiled liquid wax contacts a moving bed of bauxite adsorbent countercurrently. Wax is then steam stripped to remove odors. Bauxite sludge is washed with naphtha to remove wax, dried, and regenerated in rotary kiln. | On stream. Process developed by Socony Mobil, costs 25-35% less to install than batch plant, has lower operating costs. |

## Heavy Organic Chemicals

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Acetic acid..... | Direct oxidation.. | Distillers Co., Ltd. Hull, England | Based on direct oxidation of light petroleum fraction. Differs from Celanese process in that Celanese feeds lower hydrocarbons such as butane. | Cost $6 million. On stream by early 1962. |
| Acetic acid..... | Submerged fermentation | Chiayi Solvent Works Chia-Yi, Taiwan | Submerged fermentation and liquid-liquid extraction produces low-cost acetic acid from cheap molasses or ethyl alcohol. Special bacteria strain is introduced into mash containing 1-2% ethyl alcohol, 1-2% molasses. At 10% acid, mash is extracted with ethyl acetate (continuous countercurrent). Distillation produces glacial acetic acid. | Plant is one of three 1-2 ton/day plants built in Far East in 1959. |

## Heavy Organics—Continued

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Acrolein | Catalytic | | Special bismuth-phosphorus-molybdenum catalyst is used to make acrolein from propylene at substantially lower costs than other methods. | Developed, patented and piloted by Standard Oil Co. of Ohio. |
| Acrylonitrile | Fluid-bed | Standard Oil Co. of Ohio Lima, Ohio | Low-cost refinery-grade propylene and fertilizer-grade ammonia react in fluid-bed unit operating below 930F. and 2–3 atm. Acrylonitrile recovery by distillation is relatively simple, compared with standard acetylene-HCN route. | In use at Sohio's new 40 million-lb./year. plant. |
| Acrylonitrile | One-step catalytic | Distillers Co., Ltd. Scotland | One-step catalytic reaction converts propylene to acrylonitrile. Catalyst is mixture of oxides of molybdenum and cobalt and/or a compound of molybdenum, cobalt and oxygen. | Patent applied for. |
| Agricultural byproducts | Saccharification | Waverly Associates, Inc. King George County, Va. | Products are glucose, furfural, xylose, cellulose pulp, calcium and cupric gluconate, turpentine, pine oils and sugars from corncobs, oat and cottonseed hulls, peanut shells and wood scraps. Process cuts production time, increases yield, and produces higher quality product compared with previous processes (all of which have been economically unfeasible). | Developed by Walter Schmidt. Company is looking for licensees. |
| Aromatics, coke-oven | Desulfurization | Mine Safety Appliances Co. Pittsburgh, Pa. | Benzene (or a benzene-toluene-xylene mixture) is distilled continuously in the presence of NaK, which destroys thiophene. Benzene must be dry, $CS_2$ should be removed by cheaper distillation step. | Pilot plant stage. Process makes coal tar products as pure as petroleum counterparts. |
| Aromatics, coke-oven | Desulfurization | | Process involves use of high-surface-sodium to desulfurize coke-oven aromatics such as benzene, toluene. Unlike hydrogenation, new process requires small capital investment. | Developed by U. S. Industrial Chemicals Co. |
| Furfural | Continuous digestion | Dept. of Agriculture Madison, Wis. | Wood sugar (xylose) feeds continuously to high-temperature digester. To avoid equipment fouling by solids polymerized at high temperature, heat exchange design involves teaming injection-heated reactor with recovery system using low-pressure steam. Furfural recovery is by a 2-tower distillation. | 15 million-lb./yr. pilot plant is in operation. Process utilizes wood waste and requires lower investment than conventional furfural processes. |
| Maleic anhydride | Catalytic oxidation | Petro-Tex Chemical Co. Houston, Tex. | Using fixed bed, low-cost $C_4$ feed is oxidized catalytically. Petro-Tex expects 40% greater yield than any existing benzene-fed process. | 30 million-lb./yr. plant will go on stream in mid-'61. Patent pending. Petro-Tex developed basic flowsheet, got supplementary maleic process know-how from Scientific Design Co. |
| Naphthalene | Undisclosed | Tidewater-Collier Carbon & Chemical Co. Wilmington, Del. | A 50 million-lb./yr. plant will produce high purity naphthalene from byproduct alkyl naphthalenes by patented process. Tidewater will operate; Collier developed process. | On stream by end of 1961. |
| Naphthalene | Sodium desulfurizing | Du Pont Co. | Process depends on dispersed sodium, takes three steps: dispersion, reaction and recovery. Requires about 0.5 lb. Na/100 lb. naphthalene. | Apparently through pilot plant stage. |
| Peracetic acid | Oxidation | Union Carbide Chemicals Co. Institute, W. Va. | Acetaldehyde, air and ethyl acetate react to form acetaldehyde monoperacetate (AMP). AMP is subjected to pyrolysis that produces peracetic acid, acetic acid and acetaldehyde. | Union Carbide is operating 10 million-lb./yr. plant. |
| Phenol | Benzene oxidation | | Developed by Scientific Design Co., process is described as "in effect, a direct oxidation of benzene to phenol" without the customary production of byproducts. Process claims low capital investment as chief advantage, plus adaptability to small-scale, package phenol plants. | Process details, commercial plans are undisclosed. |
| Phenol | Benzene oxidation | Japan Atomic Research Institute Tokyo, Japan | Benzene-water mix is introduced to autoclave at 30 atm. A metal catalyst transition element is added and the autoclave heated to 200–300 C. and irradiated by a cobalt-60 source. | Pilot plant indicates possibility of lower capital cost but yield is low because phenol oxidizes. |
| Phenol | Toluene oxidation | Dow Chemical Co. Kalama, Wash. | Toluene is oxidized to benzoic acid, which is converted by steam and air to phenyl benzoate at 220–250C. over a copper catalyst promoted by Mg or Co salts. Hydrolysis yields one mole of phenol and one of benzoic acid. Advantages include no byproducts. | A 36 million-lb./yr. plant due on stream mid-'62. Involves licensing arrangement with California Research Corp. |
| Phthalic anhydride | Catalytic | | New catalyst, developed by Scientific Design Co., gives high yields of phthalic anhydride from naphthalene or *o*-xylene, or mixtures of both. | First plant to use new catalyst is being designed for a European firm. |
| Terephthalic acid | Oxidation | Bergbau-Forschung Germany | Toluene is chloromethylated and oxidized with nitric acid to an easily separated mixture of 40% *o*-phthalic acid and 60% unusually pure terephthalic. Process avoids use of *p*-xylene (expensive) as feed. Product is said to be purer than any other TA, while byproducts and corrosion are minimal. | In pilot plant stage (440 lb./day). Customer to be polyester fiber manufacturer. |

## Inorganic Chemicals

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Alum, alumina | Leaching | North American Coal Co. Powhatan, Ohio | Waste coal-mining shale is leached with sulfuric acid and the product filtered. Aluminum sulfate, recovered by crystallization, contains less than 0.005% iron. Alum can be thermally decomposed to alumina while acid values are recycled to the leaching section. Developed by Marvin Udy. | Low soda content of this alumina makes it suitable for reduction to aluminum metal or for use in ceramics. A 40,000-ton/yr. alum plant is under construction. |
| Ammonium sulfate | Oxidation | Spanish Pyrites Co. Madrid, Spain | Clean, cool $SO_2$-containing gas combines with organic solvent to form basic sulfite. Air oxidation then gives basic sulfate. Decomposition with $NH_3$ frees solvent, yields $(NH_4)_2SO_4$. Process bypasses $H_2SO_4$. | Pilot plant stage, but a 50,000 ton/yr. plant is in design. Process is patented, licensed. |

## Inorganics—Continued

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Beryllium | Crystallization | ..... | Impure beryllium hydroxide is dissolved in glacial acetic acid and insoluble impurities filtered out. On cooling, crystallized beryllium acetate is water-washed, then redissolved and recrystallized from acetic acid. Acetate is refluxed with boiling water to produce pure hydroxide. | Developed by General Electric Co. |
| Boron phosphate-silica ceramic | Firing | ..... | Silicon and boron phosphate powder are mixed, melted, and poured into $H_2O$; resultant nodules are pulverized and fabricated with binders by conventional ceramic forming techniques. A second firing causes boron phosphate to recrystallize from the glass. | Developed at Rutgers University. Other laboratories are researching. Competes with fused silica as insulating material. |
| Carbon bisulfide | Catalytic | Taylor Fibre Co. Norristown, Pa. | Process uses any feed with a low hydrogen-to-carbon ratio, such as gas oil or fuel oil, so that fewer moles of $H_2S$ per mole of $CS_2$ are formed than with conventional methane feed. This reduces size of purification equipment and eliminates need to purify feed. Process could be used in small on-site units at the consumers' plants. | Laboratory scale but available for pilot plant. Developed by C. M. Thacker. |
| Coke | Circular coker | Salem-Brosius, Inc. Dorchester, Pa. | Continuous process uses a circular furnace of 70 ft. dia. 5 ft. high with bed of coal 4–8 in. thick. Bed completes revolution every 1–3 hr. Coal fed into one side, passes through temperatures to 2,400 F., and emerges as coke from the other side. Byproducts aren't recovered, but process is still profitable. | Developed by Salem-Brosius Inc. and Whitney & Kammerer, Inc. A semicommercial pilot plant (15–16 tons/day coke) slated for operation by mid-December 1960. |
| Colloidal silicon dioxide | Combustion | N. J. Zinc Co. | Dry process gives a low-density material valuable in rubber, paint, plastics, paper coatings and greases. A briquette of 50% sand, 50% coal is heated to 1,500 C. in an electrothermal resistance furnace, and sulfur is added as vapor, liquid or powder. SiS vapor is burned in air, which produces silica fume. | U. S. Patent 2,912,342. |
| Diammonium phosphate | Modified wet-acid | Virginia-Carolina Chemical Co. Mulberry, Fla. | Usual wet-acid process, but with several undisclosed new features; makes 18–46–0 fertilizer. | ..... |
| Diammonium phosphate | Ammoniation | ..... | Phosphoric acid is partially preneutralized with ammonia, followed by complete ammoniation in a TVA-developed ammoniator-granulator drum. Heat of reaction supplies most of the heat necessary for drying. Process works on wet-process or furnace phosphoric acid. | Developed by TVA. |
| Fine powders | Spray drying | J. S. & W. R. Eakins, Inc. Brooklyn, N. Y. | Solid-bowl centrifuge dewaters fine solids to make a heavy paste. Then paste is fed into a spray dryer through a new "highly efficient" two-fluid nozzle, which has low steam requirement per pound of paste. | Developed by Eakins with Proctor & Schwartz, of Philadelphia. Eakins plant is on stream producing paint pigments. |
| Graphite, molded | Carbonization, crystallization | ..... | Carbonaceous material is combined with furfuryl-alcohol binder and heated to 5,000 F. Without intermediate cooling. Process sidesteps heating and cooling steps required with coal-tar-pitch binder; thus reduces time and cost usually involved in making molded graphite parts. | Developed by Armour Research Foundation for AEC. |
| Graphite, high density | Undisclosed | ..... | Recrystallizing conventional graphite by a classified (U.S. Air Force) process gives product that is structurally useful at 5,500 F. | Developed by National Carbon Co., initial use is in rocket nozzle inserts. |
| Gypsum | Byproduct recovery | Barrett Div., Allied Chemical Corp. Claymont, Del. | Process is based on separation and neutralization of corrosive acids contained in gypsum after it leaves filters in wet-process phosphoric-acid plant. | Plant under construction. |
| Hydrofluoric acid | Buss (Swiss) | Dixon Chemical Co. Paulsboro, N. J. | Process is a variation of the standard route via acid-grade fluorspar and sulfuric acid using a new continuous acidulator. | Plant due on stream early in 1961. |
| Hydrogen, purified | CO removal | ..... | Carbon monoxide is converted to $CO_2$ catalytically in presence of air to yield hydrogen with less than 10 ppm. CO or $O_2$. Platinum, ruthenium and rhodium are effective catalysts. | Developed by Mississippi Chemical Co. and Engelhard Industries. |
| Hydrogen, ultrapure | On-site generation | Commercial Steel Treat Co. Detroit, Mich. | This small unit can be installed in consumer's plant, thus eliminating the need to buy $H_2$ in cylinders. Process yields 99.99% pure $H_2$ from dissociated ammonia at a cost competitive with electrolytic hydrogen. | Developed by Cryogenerators Inc., New Rochelle, N. Y., generator is now on market. |
| Phosphoric acid | Solvent extraction | Tokyo Soda Manufacturers Co. Tokyo, Japan | Phosphate rock is dissolved in aqueous HCl, and the solution passes through mixer settlers where it contacts organic solvent. $H_3PO_4$ enters the solvent, leaving $CaCl_2$ and HCl in aqueous phase. Water wash and distillation give final product. Higher yield and purer product are claimed over conventional wet-acid process. | Pilot plant operation. Commercial plant in Japan has been licensed by Israel Mining Industries. |
| Pickle liquor | Vapor-compression recovery | Hanlon-Gregory Galvanizing Co., Pittsburgh, Pa. | Sulfuric acid is recovered by vacuum evaporation of water from waste steel pickling liquor. Low temperature reduces corrosion; compression and recirculation of vapor lessens steam load. | 4,000 gpd. plant in operation. |
| Pickle liquor | Electrolytic recovery | Two plants in Austria | Iron is recovered, and $H_2SO_4$ generated, in a process using an Hg electrolytic cell to treat waste pickle liquor. Plating out iron in usual processes is a problem, but in Hg-cell process, intermediate amalgam formation allows plating out in secondary circuit where pH can be controlled. | Developed by Siemens & Halske, the process has been proved in two Austrian pilot plant installations. |
| Salt | Recrystallization | International Salt Co. Avery Island, La. | Rock salt slurry is heated, then goes into a saturator, where all the salt dissolves and a portion of $CaSO_4$ separates. Complete separation of salt and $CaSO_4$ is made in a 2-effect evaporator, producing 99.99% pure NaCl. | Plant has capacity of 15 tons/hr. |

## Inorganics—Continued

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Silicon carbide, nitride-bonded | Undisclosed | The Norton Co. Worcester, Mass. | New process produces nitride-bonded silicon carbide refractory at about ¾ the cost of previous process making it economically feasible as lining in aluminum reduction cells for which it is well suited. | On the market. |
| Sulfur | $H_2S$ adsorption | | $H_2S$ is adsorbed on synthetic zeolite, then stripped from adsorbent by $SO_2$ and reduced to molten sulfur. | Developed by Krell and Associates, Houston, Tex. Pilot plant being built in Calgary, Alta. |
| Tetrafluorohydrazine | Fluid bed | Stauffer Chemical Co. | Nitrogen trifluoride ($NF_3$) reacts with carbon in a fluidized bed. The resultant $N_2F_4$ is separated from its byproducts, $CF_4$ & nitrogen oxide, plus unreacted $NF_3$, by fractional distillation. Reaction occurs at 400 C., ± 10 C. | Bench scale reactor; patents pending, development quantities available up to 100 lb. |
| Thorium hydrate | Techmanix | Sawyer Petroleum—Techmanix Corp. | "New and simpler" process makes better than 90% pure hydrate. | Pilot plant stage. |
| Titanium dioxide | Continuous leaching | Continental Titanium Corp., Montreal, Que. | Process involves continuous leaching of ilmenite to produce low-iron $TiO_2$, followed by continuous purification to produce a pigment-quality product. | Continental Titanium Corp., Montreal, Que., is building a $2-million, 10-ton/day plant in Quebec, scheduled for operation in 1961. |
| Vanadium pentoxite | Roasting | Susquehanna Western Corp., Salt Lake City, Utah | Slag from phosphorus furnaces with 3–5% V is treated in a Bessemer-type converter, yielding a slag with 12–14% V. This is roasted with NaCl to form soluble vanadate. After water leaching, vanadate solution is purified by solvent extraction and fired to form vanadium pentoxide. | Process was developed by Minerals Engineering Co. which with Susquehanna Western Corp. is building new plant in Salt Lake City. |

## Metals

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Aluminum | Direct reduction | | Process bypasses alumina-from-bauxite extraction step. Bauxite is partially reduced electrically, converting 50% of the Al content to metal. The mass then contacts $AlCl_3$ vapor at over 1,000 C. at about 1 atm. Aluminum reacts with vapor to form volatile AlCl. Condensation of AlCl against molten Al reverses reaction, forming $AlCl_3$ and Al. . . | Developed by Aluminium, Ltd. which is building an 8,000-ton/yr. plant in Arvida, Que. |
| Beryllium | Flotation-leaching | Beryllium Resources, Inc. Topaz Mt., Utah | Two-stage flotation upgrades 1% BeO ore to 10% BeO. Concentrate is then leached with sulfuric acid, and the dissolved fluorine, manganese, iron and potassium salts are removed by undisclosed multistep process. Recovery is 89–91% from ores. | Developed by Beryllium Resources, Inc., working with Brush Beryllium. |
| Ceramic-metal alloy | Metallurgical | Horizons, Inc. Cleveland, Ohio | Aluminum oxide fiber is combined with 80% nickel-20% chromium to form an alloy similar in concept to glass fiber reinforced plastics. | Company has licensed an unnamed East Coast firm to make the high-temperature ceramic fibers. |
| Columbium | Fluid-bed reduction | Nova Beaucage Mines, Ltd. Lake Nipissing, Ont., Canada | $Cb_2O_5$ ore is chlorinated; Ta & Cb chlorides are separated by distillation; Cb pentachloride is reduced with hydrogen in fluid bed of columbium seed pellets at 1,500 F. | Developed by Battelle Memorial Institute. Now in pilot plant stage. |
| Copper | Oxygen smelting | | Oxygen lance removes impurities such as sulfur in copper smelter, also enriches burner combustion to produce more furnace heat in shorter time. | Kennecott Copper Co. is building a $750,000 pilot plant; Anaconda is testing scheme. |
| Ferro-chrome alloys | Electric-smelting | Strategic Materials Corp. Niagara Falls, Ont., Canada | Process uses abundant low-grade (1% Ni, 1% Cr, 25–30% Fe) ores found in North America instead of high (38%) chrome ores now imported from Africa and Turkey. | Developed by Strategic-Udy. A 50-ton/day installation is now under construction. |
| Iron ore | Grate-kiln beneficiation | Humboldt Mining Co. Ishpeming, Mich. | Process forms iron-ore pellets suitable for blast furnace operations. Beneficiated iron ore is mixed with bentonite (about 0.5%) as binder, and mixture is formed into pellets by balling mill. Pellets feed onto traveling chain grate for drying and then into rotary kiln for fusion. | Operational in one plant at 1,000 tons/day. Will be installed in another. |
| Magnesium | Ferrosilicon reduction | Alabama Metallurgical Corp. Selma, Ala. | The Pidgeon process, now for the first time economical, operates batchwise. Dolomite is crushed, calcined to magnesium oxide and calcium oxide, and briquetted with ferrosilicon. Briquettes are fed to reduction furnace operated under vacuum. | Alamet's plant has 6,000-ton/yr. capacity. |
| Pig iron | Orcarb direct reduction | Swindell-Dresser Corp. Indianola, Pa. | Process bypasses blast furnace. High-volatile coal and fine ore are bonded in pellets and then passed through a rotating kiln followed by an electric-arc furnace for final smelting. Power saving is 500 Kwh./ton. Key step is pelletizing: Coal is heated in rotating retort, melts and comes in intimate contact with fine ore particles, forming pellets. Process can also be used for any process requiring heat and carbon. | 150-lb./hr. pilot plant in operation. |
| Stainless steels, super-weldable | Undisclosed | Westinghouse Electric Corp. Pittsburgh, Pa. | New "Kromare" 16 Cr-20 Ni stainless-steel alloys have been developed to overcome hot cracking during welding. These are a family of stainless steels with a variety of alloying elements, such as manganese and molybdenum. | Research and development stage. |
| Steel | Open hearth | Ford Motor Co. Detroit, Mich. | Use of burned lime instead of limestone for flux, along with oxygen-natural gas combination lances, boosts production of open hearths. This is achieved through higher temperatures, hence reduced heating time. Ups output of 200-ton furnace from 20 tons/hr. to 60 tons/hr. | In use on 200-ton furnace and experimental on 400-ton furnace. |

## Metals—Continued

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Steel..... | Stora-Kaldo basic oxygen converter | Societe Lorraine de Laminage Continu Seremange, France | Shaped like Bessemer converters, the S-K units operate about 17° from the vertical and rotate on their longitudinal axis during a blow. Advantages claimed (over the Linz-Donawitz process) are 2–4% higher ingot yields and greater metallurgical control. | Two 110-ton converters in operation at Seremange. |
| Titanium..... | Welding fabrication | F. W. Glitsch & Sons Dallas, Tex. | Process, developed by Titanum Metals Corp., enables very thin layer of titanium to be joined to carbon steel by using interlayer of vanadium. Glitsch plans to use process in fabricating Ti-lined steel equipment. | Chicago Bridge & Iron Co. in 1959 announced somewhat similar process using silver interlayer. |
| Tungsten and molybdenum, forgeable | Electron-beam refining | Stauffer-Temescal Co. Richmond, Calif. | Crude metal bar is placed in chamber and melted by electron beam; molten metal drips into water-cooled crucible. Impurities are vaporized and drawn off into a vacuum, while the pure metal solidifies. | Process reduces grain size. This boosts shock resistance, makes metals easier to shape. |

## Nuclear

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Heavy water..... | Ammonia extraction | ..... | Deuterium is extracted catalytically from ammonia synthesis gas with liquid ammonia at −40 F. Ammonia is further enriched by contact with a deuterium-loaded recycle gas. Half of the rich ammonia is vaporized and deuterium concentrated to 75% by distillation; the other half gives up deuterium to recycle gas stream at 212 F. | Developers, Constructors John Brown of London, England, have preliminary designs for a 31-ton/yr. plant costing $6 million. Process will make $D_2O$ for a little less than Savannah R., in smaller plant. |
| Nuclear fuel..... | Pelletizing..... | ..... | A coating of impermeable alumina or pyrolitic graphite, applied in fluidized bed to uranium dioxide or carbide nuclear fuel particles, prevents escape of fission particles. | Developed by Battelle Memorial Institute, Columbus, Ohio. |
| Plutonium-uranium reactor fuel | Pelletizing..... | Carborundum Co. Niagara Falls, N. Y. | Plutonium oxide from AEC is converted into plutonium carbide powder and mixed with proportionate amounts of uranium carbide powder. Mixture is then fabricated into pellets. | ..... |
| Radioiodine I–131 | Irradiation..... | Abbott Laboratories Oak Ridge, Tenn. | Uses target material of Te-130 in high neutron flux at G.E.'s test reactor in San Jose, Calif. Irradiated Te contains I-131. Abbott claims new oxidizing medium permits separation of I-131 from Te target metal. | In commercial production, selling price is about 20% lower than AEC material. |
| Uranium dioxide.. | Reduction..... | Eldorado Mining & Refining, Ltd. Canada | Process starts with ammonium diuranate, uses a catalyst and pressure to aid reduction to uranium dioxide. Lower cost for reactor grade $UO_2$ is promised. | Laboratory process ready for scale-up. |
| Uranium hexafluoride | Fluid-bed..... | Allied Chemical Co., General Chemical Div. Metropolis, Ill. | Fluid-bed processing is used for: (1) Reduction of $U_3O_8$ to $UO_2$, (2) Hydrofluorination of $UO_2$ to $UF_4$, and (3) Fluorination of $UF_4$ to $UF_6$. Uranium hexafluoride then is purified by distillation. Process eliminates need to purify $U_3O_8$ concentrates by solvent extraction before conversion to $UF_6$. | First privately owned $UF_6$ facility, Allied's plant has 6,000-ton/yr. capacity. Fluid-bed techniques developed with Argonne Nat. Lab. |
| Uranium metal, enriched | Reduction..... | Mallinckrodt Nuclear Corp. Hematite, Mo. | Process involves reducing uranium hexafluoride with an undisclosed liquid organic reducer instead of the usual hydrogen. As a result, there's no need to handle hydrogen fluoride or to separate uranium tetrafluoride dust in the byproducts. | Plant is in operation at Mallinckrodt's Hematite, Mo., facility; will supply initially 1,200 Kg. of uranium to Argonne National Laboratory. |

## Petroleum & Natural Gas

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Blending stock, high octane | Isomerization.... | Pure Oil Co. | Straightrun naphthas or $C_4$–$C_6$ feeds are upgraded at "temperatures far below those used in catalytic reinforcing processes." An active hydrogenation metal catalyst selectively isomerizes n-$C_5$ and n-$C_6$ to their respective high-octane isomers. | Developed by Pure Oil Co. Direct costs range from 4.2 to 5.6¢ per research-octane-number increase per barrel. Payout time: 3 yr. |
| Fuel gas..... | Synthetic..... | ..... | Natural or recycled product gas and steam react at 1,800 F. over a nickel catalyst. After reforming, water-gas shift eliminates CO, MEA removes $CO_2$. Resulting hydrogen and incoming feed (natural gas, naphtha, No. 1 fuel oil) react at 1,300 F. to produce liquid and gas fractions. | Piloted by Institute of Gas Technology, Chicago, Ill. |
| Gasoline..... | Catalytic hydrocracking | Universal Oil Products, Inc. San Antonio, Tex. | Process leaves no catalytic deposits, yields less light hydrocarbon gases, gives olefin-free products. Complex middle distillates hydrocrack to better than 100% yields of high octane. Complete recycling of cuts boiling above gasoline won't sacrifice yields or quality. | Operating costs total 31¢/bbl. for a 9,800-bbl. plant using 400–650 F. virgin distillate. Payout time: 1.5 years. |
| Gasoline..... | Unicracking..... | Union Oil Co. of California Brea, Calif. | In a two-stage reaction, this fixed-bed process upgrades catalytic cycle oils, heavy naphthas and gas oils to high-quality gasoline. Undisclosed catalyst combines hydrogenation and cracking activities, and can be repeatedly regenerated. | Operating costs range from 23.9 to 32.4¢/bbl. |
| Gasoline, diesel and jet fuels | Unicracking..... | Union Oil Co. of California Brea, Calif. | Process needs no separate feed pretreatment, regenerates catalyst by conventional means, and is said to make products more efficiently than do catalytic or thermal cracking methods. It gives no low-value fuel oil components. | Process available for license. |
| Gasoline, furnace oil | "H-Oil" hydrogenation | ..... | Using residual oil feed, process combines ebullating catalyst bed, internal recycle and catalyst staging to solve technical difficulties previously encountered. | Developed by Hydrocarbon Research Co., which is negotiating license. Operation expected in late 1961. |

## Petroleum & Natural Gas—Continued

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Gasoline, heating oil | Model II fluid coking | Esso Research & Engineering Co. Linden, N. J. | This redesign of the original process makes for equipment which is much more compact, requires smaller plot area, can be installed and operated for up to ⅓ less than the original. Basic process for converting residual oils into gasoline and home-heating oil remains unchanged. | Developed through pilot stage. |
| Gasoline, middle distillate fuels | Lomax..... | Universal Oil Products, Inc. Des Plaines, Ill. | The Lomax (light oil maximizing) process of hydrofining uses a fixed-bed catalyst in an $H_2$ environment under pressure, without catalyst deposit. Gives low-olefin products and mostly branched isomers in the light naphtha range. | Apparently through pilot plant stage. |
| Gas sweetening... | Molecular sieve... | Linde Co. Houston, Tex. | Hydrocarbons flow down through molecular sieve which adsorbs sulfur compounds. Wastes are removed periodically by a hot gas purge, and the bed is cooled by the high-sulfur liquid feed. Problems of caustic scrubbing technique are said to be eliminated. | Report to AIChE at Tulsa, Okla., meeting. |
| Methane, high-purity | Cryogenic distillation | Solvay Process Div., Allied Chemical Corp. Moundsville, W. Va. | Product from column serves as refrigerant for the natural gas feed. Temperature of distillation is about −200 F. Product has 100 ppm. impurities compared with 1,000–12,000 ppm. for other processes. Capacity: 500 scfm. | In construction stage. Installed and designed by Air Products Inc., it is the fourth such plant in the country. Product is feed for chlorinated hydrocarbons plant. |
| Natural gas..... | Absorption of $CO_2$ | El Paso Natural Gas Co. Terrell County, Tex. | $CO_2$ is absorbed from natural gas by such new solvents as propylene carbonate, glycerol triacetate, butoxy diethylene glycol acetate, and methoxy triethylene glycol acetate. Feed gas, counter-currently treated by one of these solvents, is flashed in an intermediate tank, passes through a power-recovery turbine to a flash vessel that operates at atmospheric pressure. Air stripping is used occasionally. No heat is supplied for solvent stripping. | Fluor Corp. owns three patents. Natural gas with 53% $CO_2$ has been stripped to less than 0.25% $CO_2$ content. Cost, $/Mscf.: $0.020 to 0.043. |
| Natural gas..... | Scrubbing..... | Transwestern Pipeline Co. Fort Stockton, Tex. | Plant, based on the Italian-developed Giammarco-Vetrocoke process, removes $CO_2$ and $H_2S$ from natural gas by scrubbing with potassium or sodium carbonate solutions activated by salts of multivalent metals. Utility requirements are much lower than those of competitive routes. | First plant in the Western Hemisphere to use process. Plant can sweeten 180 million scfd., reducing $CO_2$ to 2% and $H_2S$ to 0%. |
| Oil..... | Short cycle adsorption from natural gas | Phillips Petroleum Co. Bartlesville, Okla. | Oil from natural gas containing as little petroleum as 0.1 gal./1,000 cu. ft. can be processed economically by short-cycle adsorption chamber with internally insulated bed. Requires two adsorption towers, furnace, gas pump, heat exchangers. | Report to AIChE at Tulsa, Okla., meeting. |
| Petroleum coke... | Desulfurization... | ..... | To reduce sulfur in petroleum coke, material is calcined in presence of sodium sesquicarbonate. Product is then leached with water and dried, yielding coke with less than 2% S. | Developed by Research Dept. of Socony Mobil Oil Co. |
| Petroleum coke... | Fluid-bed desulfurization | ..... | As much as 90% of the sulfur in petroleum coke can be removed by calcining at 1,550 F. using hydrogen as the fluidizing gas. Desulfurizing is improved by reducing particle size and increasing pressure and space velocity. | Developed at Institute of Petroleum, Zagreb, Yugoslavia. |
| Premium cracking stocks | Catalytic hydrodesulfurization | Gulf Research & Development Co. | Vacuum and atmospheric residues of Kuwait crude are stripped of their 5.5–4.6% sulfur content and reduced to a viscosity approximately the same as that of No. 6 fuel oil in a catalytic fixed-bed system at 500–1,000 psi. No details on operation have been disclosed. | Operation is reported similar to that of furnace-oil desulfurization. |
| Petroleum gas, liquefied | Dehydration and stripping | Sun Oil Co. Laverne, Okla. | Inlet gas—about 86% $C_1$ and 6% $C_7$—dehydrates in a vertical contactor with a 20 gpm. triethylene glycol flow. Chilling to 38 F. with outlet gas precedes absorption. | Plant handles 150 MM cf. gas daily; fully automated, this process requires only two people for running. |
| Refined oil..... | Desulfurization... | Shell Oil Co. Houston, Tex., Wood River, Ill., and Shelburn, B. C. | Oil at 600 psig., 700 F. containing dissolved hydrogen passes through a fixed catalyst bed which promotes desulfurization reaction, removing 90% of sulphur. | Houston plant handles 30,000 bpd. of furnace or diesel oil. |
| Water gas..... | Continuous coal gasification | British Gas Board..... | Process involves forcing powdered, low-grade coal with air, oxygen or steam through molten slag bed. Coal gasifies completely and continuously leaving ash as part of slag bed. | A 2-MM-scfd., $630,000 pilot plant will be in operation in late 1961. Process is under study by London Research Station of Britain's Gas Board. |

## Plastics, Resins & Rubber

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Olefin block copolymers | Ziegler catalysts.. | Farbwerke Hoechst Germany | By regulating temperature, polymers grow remarkably slowly; polymerization can be stopped at any point while blocks of any homo- or co-polymer are added to the chain. | Research stage. |
| Plastics, molded.. | Engel..... | Spencer Chemical Co. Orange, Tex. | A powdered thermoplastic (especially polyethylene) is fused in an oven. Can be adapted to forming hollow articles of almost any size. | Pilot plant under construction to develop improved grades of powdered polyethylene required by the process. |
| Polyether urethane foams | Controlled polymerization | ..... | New concept of "net controlled polymerization" (CPR) allows production of urethane foams that are uniform and high quality. Difference between reserve basicity of the polyglycol and the active hydrolyzable chloride of the diisocyanate represents the net CPR for the mixture. | Developed by Dow Chemical Co. |

## Plastics, Resins & Rubber—Continued

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Polyethylene, liquid | Oxidation..... | Delka Research Corp. Glen Rock, N. J. | Process creates, by controlled oxidation, liquid fatty acids or polyalcohols from polyethylene. Reactive hydroxy sites allow cross-linking with methanes and epoxies. Coatings formulated with new resins dry to hard, plastic surfaces that withstand 400 F. and numerous chemicals. | Resins are on the market. |
| Polyethylene, powdered | Precipitation.... | U.S.I. Chemicals, Inc. Tuscola, Ill. | Polyethylene is ground to 50–200 mesh in a combination squirrel cage mill and hammer mill grinder, then conveyed pneumatically so air can provide some cooling. Very fine particles are made by dissolving polyethylene pellets in an unidentified hot hydrocarbon solvent. When large volumes of cold water are added, fine particles precipitate. | 2 million-lb./yr. facility will soon go on stream at Tuscola. |
| Polyethylene film. | Irradiation..... | W. R. Grace & Co., Cryovac Div. Simpsonville, S. C. | Film is made shrinkable by irradiating broad polyethylene tape, using a 2-mev. electron-beam generator, then stretching tape biaxially. | 1 million lb. produced for test marketing. Film features high clarity and 10,000-psi. tensile. |
| Polyisoprene..... | Dehydrogenation | Shell Chemical Co. Torrance, Calif. | High purity iso-amylene is dehydrogenated. Iso-amylene is cut from $C_5$-rich refinery stream, purified in two stages of distillation in 120-ft. tall tower containing 50 Glitch Ballast trays. Polymerization of monomer takes place over a Ziegler-type catalyst. | Plant nearing completion. |
| Polymers, high-temperature | Undisclosed..... | Artrite Resins Ltd. Camberly, Surrey, England | Process and composition of product are secret, but polymers are said to contain phosphorus and boron. Product withstands 1,110 F. and has molding characteristics similar to phenolic resins, plus high thermal strength and thermal-shock resistance. | Laboratory scale. Product expected to replace ceramics in missiles and high-speed aircraft. |
| Polyolefins, flameproof | Farbwerke Hoechst | ..... | Process involves addition to polymer of octachlorodiphenylene dioxide and at least one $O_2$ or S compound of an element of periodic table Group V. | Australian patent application 55,554/59. |
| Polypropylene.... | Continuous polymerization | Humble Oil Co. Baytown, Tex. | Propylene gas is dissolved in an inert liquid and mixed with suspended catalyst particles. By proper selection of polymerization conditions, almost any ratio of atactic, isotactic and stereoblock polymer can be produced. | 40 million-lb./yr. unit now operating. |
| Polypropylene... | Spark discharge polymerization | ..... | Process uses metal-halide catalyst (titanium tetrachloride), a deoxidation agent (powdered aluminum) and alkyl halide (ethylene bromide). Unique feature is a 100 to 300 v. spark discharge that boosts yields of polypropylene (average molecular weight of 500,000; melting point of 330 F.) and "enhances effectiveness of the catalyst system." | Developed by Tokuyama Soda, a Japanese firm, in 1 ton/day pilot unit. Plans are for building a 10,000 ton/yr. plant in early 1961. |
| Synthetic rubber. | Solvent polymerization | ..... | New process bypasses crumb-type, cumbersome coagulation of conventional emulsion processes. Solvent is stripped from mix of solvent and cement-like elastomer which has been extruded over a 200 F. water bath. Strings of elastomer combine to form continuous sheet when dried in a low-cost air dryer for less than 10 minutes. | Developed and piloted by Crawford & Russell, Inc., Stamford, Conn. To be licensed. A 300,000 ton/yr. plant would cost $1½ million less than conventional plants. |
| Synthetic rubber. | Concentration, agglomeration | U. S. Rubber Co., Naugatuck Chem. Div. Naugatuck, Conn. | Key is use of special molecular weight polyvinyl methyl ether during evaporation process so that agglomeration occurs at same time water is removed. | 5–10% cheaper than natural rubber foam. |
| Teflon, shaped.... | Cold press..... | Akyd Set Resins Ardsley, N.Y. | Process key is a method of cold pressing polymers by fluid pressure through an elastic disphragm to compress granulated plastic into preforms of uniform density. | Process ready to license. |
| *Trans*-polybutadiene | Solution polymerization | Phillips Chemical Co. Bartlesville, Okla. | Details aren't disclosed, but solution process gives a product with about 90% *trans* content. | Semi-commercial plant. |

## Pulp & Paper

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Fiber board..... | Wood chip conversion | U. S. Plywood Corp. Redding, Calif. | Fiber board is made from waste wood chips of sawmills and plywood plants. Binder is from pulp mills' waste sulfite liquor. | Pilot plant & market tests. |
| Hardboard..... | Air felting..... | Bowater Bond Co. Catawba, S. C. | Wood fiber is metered pneumatically through five ducts, then is felted continuously into the desired mat width and thickness. A continuous multi-layer fiber mat is built up as the screen passes through the four sections of the felter. | Commercial. |
| Pulp..... | Fluff drying..... | Waldorf-Hoerner Paper Products Co. Missoula, Mont. | Fluffed pulp passes through center chamber of main dryer, back through intermediate chamber, then forward again through outside section. Particles dry selectively, becoming air-borne in proportion to size. First time process has been used for high-quality chemical pulp. | Dryer is rated at 25,000 lb./hr. water evaporation. |
| Pulp, bleached... | Four-stage bleaching | Mead Corp. Chillicothe, Ohio | Bleaching sequence of chlorination, caustic, calcium hypochlorite and chlorine dioxide is used to make modified hardwood soda pulp with brightness in 86–88 G E range. | Capacity of system: 500 tons/day. |
| Pulp, bleached kraft | Bleaching | British Columbia Forest Products, Ltd. Crofton, B.C., Canada | Production of calcium hypochlorite in a continuous, controlled system gives better control of bleached pulp quality and keeps operating and chemical costs at a minimum. | Designed by BCFP with H. A. Simons, Ltd., and Hooker Chem. Corp. Plant to produce 40,000–200,000 gpd. liquor has been in continuous operation since Jan. '58. |
| Pulp, paper..... | Hi Fiber..... | ..... | Process developed by Dorr-Oliver. Chips are mechanically impregnated with lime liquor by spraying in a roller mill. Second roller mill with differential roll | Has been pilot-planted in 15 ton/day unit at an unidentified mill. |

## Pulp & Paper

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| | | | speed defibers chips. Dorr-Oliver claims $5–$6 saving per ton due to using lime rather than NaOH, plus 10% lower capital costs and 75% power saving. | |
| Pulp, soda base | Two-stage..... | Stora Kopparberg Skutskar, Sweden | Two-stage sodium bisulfite process and special mechanical depithing technique overcome problem of high resin content of pine. Chemical recovery is almost 100%, eliminating pollution problem. | Mill is being expanded to 80,000 metric tons/yr. |
| Pulp, sulfite..... | Chlorine dioxide bleaching | Gaspesia Sulfite Co. Chandler, Que., Canada | Plant uses five-stage bleaching, adding hypochlorite after $ClO_2$ bleach; makes a paper-grade sulfite pulp with superior strength and color properties compared to hypochlorite-bleached sulfite pulps. | Commercial. |
| Pulp, sulfite..... | Magnefite..... | ..... | Process is same as standard magnesia flowsheet except for a new liquor fortification step. Makeup $SO_2$ is added to the acid water from cooling tower to give 5% $SO_2$ in the acid returned to the digester. | Developed by Babcock & Wilcox; installed in Wisconsin and Swedish plants. |
| Pulp, sulfite (neutral) | Mead..... | Mead Corp. Lynchburg, Va. | A fourth absorption tower and venturi scrubber have been added to reduce unpleasant odor. Can now also be adapted for acid pulp, recovering chemicals. | Plant on stream. |
| Pulp, sulfite (neutral) | Sivola..... | Rauma-Repola Rauma, Finland | Two stage digestion process, with chemical recovery, licensed by Combustion Eng. Corp., allows variety of woods for feed, reduces cooking time, requires less steam and bleach. | Present plant being expanded, second Finnish plant going up. |

## Synthetic Fibers

| Product | Process | User | Features | Remarks |
|---|---|---|---|---|
| Acrylic fiber..... | Continuous polymerization | ..... | Process, though secret, is believed to involve a new catalyst for acrylonitrile polymerization. | Von Kohorn International Corp. developed process, is testing it on semicommercial scale. |
| Polyamides..... | Undisclosed..... | Du Pont Co., Chemstrand Co., Allied Chemical Corp. | New polyamides with melting points up to 600 F. are being developed and tested for tire cord in aircraft tires. | Developmental stage. |
| Polyolefin fibers.. | Stretch spinning.. | Montecatini Co. Italy | Polyalkylimines are incorporated in molten polyolefin, which is extruded, stretched and subjected to finishing operation. | Patent applied for. |
| Wash-and-wear wool | Chemical treatment | Fabric Research Laboratories Dedham, Mass. | After optimization of fabric geometry, a two-step chemical treatment further improves the wool fabric. (1) Treat in 4% potassium permanganate solution saturated with NaCl to improve shrinkage properties. (2) Treat with ethanolamine-sulfite to impart wrinkle resistance. | Development stage. |

## Technology

| Operation | Equipment | User | Features | Remarks |
|---|---|---|---|---|
| Air pollution measurement | Hydrocarbon analyzer | American Cyanamid Co. Stamford, Conn. | Process is based on electrical conductivity of charged particles present in hydrocarbon flame. When voltage is applied on ionized particles, unit indicates amount of hydrocarbons present. Detects hydrocarbon concentrations to 10 parts per billion. | Unit also detects leaks and is more sensitive than infrared analyzers in spotting explosive vapors. |
| Atomic waste disposal | Foam column.... | Atomic Energy Commission Oak Ridge, Tenn. | Foamet system is continuous and mechanically simple, hence cheaper than conventional ion-exchange process. Air or nitrogen is bubbled through the nuclear waste (a solution of metal ions), to which a surface-active complexing agent has been added. A foam containing the metal ions is produced and is continuously collected from the surface. | A $200,000 development program, has been started by AEC with Radiation Applications, Inc., developers of the idea. |
| Crude oil heating | Electric heater... | Carpco-Kewanee Inc. Cache Creek, Okla. | Treater's electrodes won't short out even when unit handles 100% water. Automatic shutoff prevents explosion when excess $O_2$ builds up in the unit. Transformer and rectifier supply 18 milliamp. at 25–30 Kv. to electrodes from 5 amp., 220-v. single phase power source. Heat is supplied only when crude is too viscous to flow. | Treater handles 1,800 bpd. of emulsified crude. Carpco-Kewanee plans to license method. |
| Distillation..... | Compressor column | ..... | Vapor is compressed as it rises through column, thereby eliminating pressure drop. | Development stage. Designed by Donald Othmer of Brooklyn Polytechnic Institute. |
| Distillation..... | Rotating-tray tower | Vulcan-Cincinnati Inc. Cincinnati, Ohio | Series of rotating trays fling liquid reflux droplets from center of column to walls. Rising vapor passes through this liquid curtain and achieves intimate contact, just as in conventional tray. Advantage is extremely low pressure drop (1 mm.), because of large percentage of open cross section in tray and because energy for vapor-liquid contact is supplied mechanically. | Tower was developed and patented by Stora Kopparbergs Bergslag, Sweden. No installations yet in U. S. Vulcan is gathering operating data in cooperation with an unidentified U. S. chemical firm. |
| Dry-photography technique | Ultra-violet..... | Horizons Inc. Cleveland, Ohio | Process uses reaction of aryl amines with free radicals generated from multihalogenated compounds, such as carbon tetrachloride, by near ultra-violet light. | 10–20 times faster than diazo method. |
| Dyeing, textile... | Ultrasonic..... | ..... | B. M. Harrison Electronics Inc. has applied for a patent on an ultrasonic dyeing process that is said to produce uniformity of color tone and saturation difficult to achieve by normal means. Process combines high temperature and "an electronic means of controlling dye concentration." | ..... |

## Technology—Continued

| Operation | Equipment | User | Features | Remarks |
|---|---|---|---|---|
| Electricity generation | Cesium-cell converter | ..... | High-power cesium cell converts fission energy directly into electrical energy at 3,500 F. with about 10% efficiency. Thermionic device operates at 90 w.—ten times the power output of usual devices of this type. | Tested and developed by General Atomic Div. of General Dynamics at San Diego, Calif. Laboratory-scale units. |
| Electricity generation | Free-radical recombiner | Energy Conversion Laboratories Detroit, Mich. | Devices produce radicals from diatomic gases via energy radiation at near room temperature, rather than usual cryogenic temperatures. 90% recombination energy can be converted to electricity on surface of thermo-electric material. | Laboratory stage. Potential uses: generators for remote locations, power plants for boats, cars, etc., and steam generators for sea-water desalting units. |
| Electricity generation | High-output fuel cell | ..... | "Radically different" electrode in hydrogen-oxygen fuel cell develops 3–5 kw./cu.ft.—about four times the present output of low-temperature cells. | Developed by Shell Petroleum (England). A 20-cell unit has been built with 0.167 in.-thick cells. |
| Electricity generation | Low-temperature fuel cell | Royal Dutch-Shell Cheshire, England | Operating with either alkaline or acid electrolytes, with $H_2$ and $O_2$ at 3 psi., current density of 70 amp./sq.ft. is obtained at room temperature; claimed to give 3–5 times more power per volume than other similar cells. | ..... |
| Electricity generation | Solid electrolyte fuel cell | U. S. Marine Corps. | New "solid electrolyte" fuel cell produces 20 w./sq. ft. of membrane surface with 50% efficiency at full load. Cell uses hydrogen and oxygen but has acidic ion exchange membrane instead of a liquid electrolyte. | General Electric Co. has developed and delivered 10 portable fuel cell power packs of this type to the Marine Corps. |
| Electricity generation | Zinc fuel cell..... | ..... | Developed by Exide Industrial Div. of Electric Storage Battery Co., fuel cell is first metal-fueled system to bid for commercial jobs. Oxygen serves as oxidizer; zinc powder with catalyst is pressed into tubes. Each cell generates 1.5 v., operates at about 80% efficiency. | Exide is working with 12 equipment manufacturers, hopes to perfect unit for use in trucks in two or three years. |
| Fuel storage..... | Underwater fuel cache | U. S. Navy Grand Isle, La. | A 1,200-bbl. bag of rubber is harnessed to the ocean's bottom by nylon webbing. Rubber flow line extends to a swivel buoy above the bag. Fuel can be pumped into the bag at 840 gpm. Hydrostatic pressure moves the fuel out. | U. S. Rubber Co. is the contractor. Another underwater storage system for 100,000 bbl. is under consideration. |
| Gas detection.... | Air density monitor | Detectogas Instruments, Inc. Houston, Tex. | No power is used when gas is not present. When density of sample differs from that of air, $N_2$-filled float trips mercury switch for alarm or ventilation. | Priced at less than $1,000. |
| Gas cleaning.... | Water scrubber... | ..... | Dust-laden gas moves downward through an annulus formed by a water-flooded disk within a tapered pipe section. Turbulent flow in annulus produces intimate gas-water contact. Disk automatically moves in tapered pipe to maintain constant delta P at all loads. Collection efficiencies of 99 to 99.5% are claimed. | Developed by Research-Cottrell, Inc., Bound Brook, N. J. |
| Hydrogen diffusion | Palladium purifier | Engelhard Industries, Inc. Newark, N. J. | Ammonia gas feed dissociates and ultra-pure hydrogen diffuses through palladium. Machine gives 70 cu. ft. of $H_2$ from 100 cu. ft. of $NH_3$ gas feed. | Initial costs, $2,275 to $35,025, depending on unit size, would be offset by savings within a year. |
| Induction-pressure welding | Induction generator-hydraulic press | Esso Research & Engineering Co. | Equipment joins 40-80 ft. pipe lengths, aligning joints for minimum mismatch. | Laboratory tests on 6⅝-in. O.D. standard-wall steel pipe. |
| Lubrication | Gas-lubricated bearings | Bristol Siddeley Engines Ltd. London, England | Until recently a laboratory curiosity, gas-lubricated bearings are being used on pumps and compressors in sizes to 8 in. dia. for pressures to 1,800 psi., temperatures to 700 C. and power to 1,750 hp. in equipment for nuclear power plants being built by Bristol Siddeley for England's Central Electricity Generating Board. | Claim for longer life, no lubrication breakdown due to radiation in reactors. |
| Molecular-sieve adsorption | Computer controller | ..... | Small, special-purpose Daystrom computer controls 24 variables in Molex process to separate normal paraffins from higher-octane branched-chain and aromatic gasoline components. Computer, called Flowcon, has four inputs and two outputs. | Design stage. Developed by Universal Oil Products Co. |
| Oil well rejuvenation | Gas-lift swabbing. | ..... | Gas generated at the bottom of an oil well lightens the whole fluid column as the gas rises. The reduced hydrostatic head in the aerated column permits the well to flow again. $CaH_2$, packaged in 1¼ in.-dia. and 24 in.-long polethylene glycol sticks, is dumped into the well where it reacts with water to form hydrogen. | Developed by Lissant and Samuelson of Petrolite Corp. Presented at ACS meeting, Cleveland, April 1960. |
| Oxidation with $O_2$ | Injection system.. | Celanese Chemical Co. Bishop, Tex. | Elaborate injection system permits use of 95% $O_2$, instead of air, for oxidizing aliphatic hydrocarbons. Oxygen increases yields with less degradation of reactants and products. System includes sparger and safety valves to hold $O_2$ below dangerous limits. | Operating on commercial scale. |
| Paper drying..... | Air-shrouded drying section | Several | Shroud is fitted to entire length and either upper or lower periphery of conventional paper-drying cylinder. Inside of shroud are a large number of nozzles directing hot air (heated by direct-fired gas heater) on to the paper web. Air is exhausted and re-circulated by slots in shroud. One such cylinder does work of three conventional steam cylinders, thus greatly reducing length of paper machine. Can be installed on both existing and new machines. | Four manufacturers: Black-Clawson Co., Beloit Co., Rice Barton Corp., and J. O. Ross Eng. Total installations: about 100, all on existing machines so far. |
| Photographic printing | Lighting system.. | LogEtronics, Inc. Alexandria, Va. | Electronic system automatically adjusts light shining through negative so that dark portions get more light; thin, underexposed parts get less light. Result: all details in negative show up in final print. | Good for improving results from electron microscopy, medical x-ray, electron diffraction. |
| Pipeline cleaning.. | Variable-diameter pipeline scraper | Service Pipe Line Co. | New design permits two scrapers to do work of six conventional scrapers, thus reducing crew size. | Device available for licensing. |

## Technology—Continued

| Operation | Equipment | User | Features | Remarks |
|---|---|---|---|---|
| Process control... | Computer controller | Aurora Gasoline Co. Detroit, Mich. | Distillation, cracking, polymerization, $H_2SO_4$ alkylation, raw material requirements, heat-exchanger performance analysis and gasoline blending operation are bossed by digital computer. Magnetic drum (1,800 rpm.) with 2,160 word storage in 20 channels is used for high-speed storage. | Bendix G-15 digital computer runs Aurora's 45,000 bpsd. refinery at Detroit. |
| Pulping..... | Inclined rotor pump | ..... | Inclined saw-tooth impeller in pump simultaneously transports and refines a wide variety of pulped fibers, ranging from wood to bagasse. About 2.5 kw./hr. are needed to produce a ton of paper pulp. | Developed by Theodor Hoelscher-Maschinenfabrik, West Berlin, Germany. |
| Rubber drying... | Mechanical screw press | Goodrich-Gulf Institute, W. Va. | Compared with usual hot-air drying of SBR polymers, the new process is much faster; carries away soluble salts with water, thus lowering ash content; keeps maintenance and product contamination low. Rubber is squeezed by a conical screw conveyor before extrusion. | An 8,000 lb./hr. extruder is in operation. |
| Saline water pretreatment | Ion exchanger | Dow Chemical Co. Freeport, Tex. | As saline water is evaporated 75%, $CaSO_4$ precipitate may be prevented by partial ion-exchange softening using evaporator blowdown as resin regenerant. | Pilot plant. |
| Steam generation. | Packaged CO boiler | ANCAP Refinery Montevideo, S. A. | Of 30,000–43,000 lb./hr. design capacity, 70% of steam is generated from waste heat and complete burning of CO gases. Installed in 4 weeks, unit is used with 5,000 bpd. fluid cat-cracker. | ..... |
| Temperature "alarm" | Silicone-based paints | Humble Oil & Refining Co. Baytown, Texas | Paints, manufactured from modified silicones and acrylic resins, cover hot surfaces, give evidence of hot spots by single irreversible color change. | ..... |
| Transport of methane | Tanker..... | Bridge Stone Tire Co. Tokyo, Japan | A 15,000 ton refrigerated tanker, second of its type in the world, is currently under construction. Total investment planned, including receiving facilities at Yokahama and Tokyo, is estimated at $14 million. | Project is cosponsored by Mitsubishi Nippon. |
| Water desalting.. | Hydrocarbon contactor | Office of Saline Water (U. S. Dept. of the Interior) | Patents have been issued to Koppers Co. on a process that involves bubbling hydrocarbon gases into salt water, thus forming plate-like crystal hydrates with water. Hydrates form at temperature higher than freezing point of water. Salt is left in brine; crystals yield gas for recycle and pure water. | ..... |
| Water desalting.. | Freezer..... | Office of Saline Water (U. S. Dept. of the Interior) | Process is said to grow larger, easier-to-separate ice crystals than other freeze processes. This is accomplished by slow, controlled crystal growth. | Developed by Scientific Design Co. and Struthers-Wells Co. A 10,000 gpd. pilot plant is under construction. One of three freeze processes being considered in OSW's demonstration plant program. |
| Water desalting.. | Freezer..... | Office of Saline Water (U. S. Dept. of the Interior) | Water is frozen by flash evaporation of butane (or isobutane) in direct contact with the feed at near-atmospheric pressure. Butane vapor is then compressed and partially used to melt the separated ice. Same advantages and disadvantages as vacuum flash process. Joint development of Blaw-Knox and Cornell's H. F. Wiegandt. | A 35,000 gpd. pilot plant is under construction by Blaw-Knox. One of three freeze processes being considered for OSW's demonstration plant program. |
| Water desalting.. | Freezer..... | Office of Saline Water (U. S. Dept. of the Interior) | Saline feed is chilled with product fresh water and reject brine. The feed is introduced to a low-pressure (3mm.) freeze chamber. About 0.5% of feed flashes, partially freezing the remainder. Resulting ice-brine slurry is washed and the ice separated. Then the ice is melted by fresh water condensed from a freeze-chamber overhead. Advantage: low energy requirement and no high-temperature corrosion and scale problem. Disadvantage: hard to separate ice from brine. | A 15,000 gpd. pilot plant is being developed by Carrier Corp. One of three freeze processes being considered in OSW's demonstration plant program. |
| Water desalting.. | Solvent extraction | ..... | Mixture of triethylamine and methyldiethylamine separates water from salt. Solvent-water solution is heated with low-grade heat, to recover fresh water. Last traces of solvent are removed by steam stripping. | Flowsheet was pioneered by Texas A & M. Report submitted by Brown & Root Co. (Houston) to office of Saline Water claims process can desalt high-salinity brackish water for $1.50/1,000 gal. |
| Water desalting.. | Dialysis..... | ..... | New dialysis membrane (made by mixing cellulose acetate with aqueous magnesium perchlorate and acetone, then casting on a glass plate) can desalt water containing 50,000 ppm. salt. Fresh water can be produced at rate of 8 gpd./sq. ft. of membrane in a single pass. | Developed by S. Loeb and S. Sourirajan of University of California at Los Angeles on a laboratory-scale unit. |
| Water pollution control | Zeta potential control | City of Waterford, N. Y. | Zeta potential (potential at the hydrodynamic plane of shear) is an indication of electric charge at the surface of an ionized particle. When it is reduced below a certain critical value, sols become unstable and produce flocs. Thomas A. Riddick has developed simple device to measure zeta potential. After measure, operator can adjust chemical treatment of water to give reduced potential and better flocculation. | Municipal plant in operation at Waterford, N. Y. |

# How to Analyze the Calculations for Batch Rectification in Tray Columns

**To separate binary mixtures by batch rectification, determine optimum conditions by examining operation at constant reflux ratio or at constant composition of the overhead product.**

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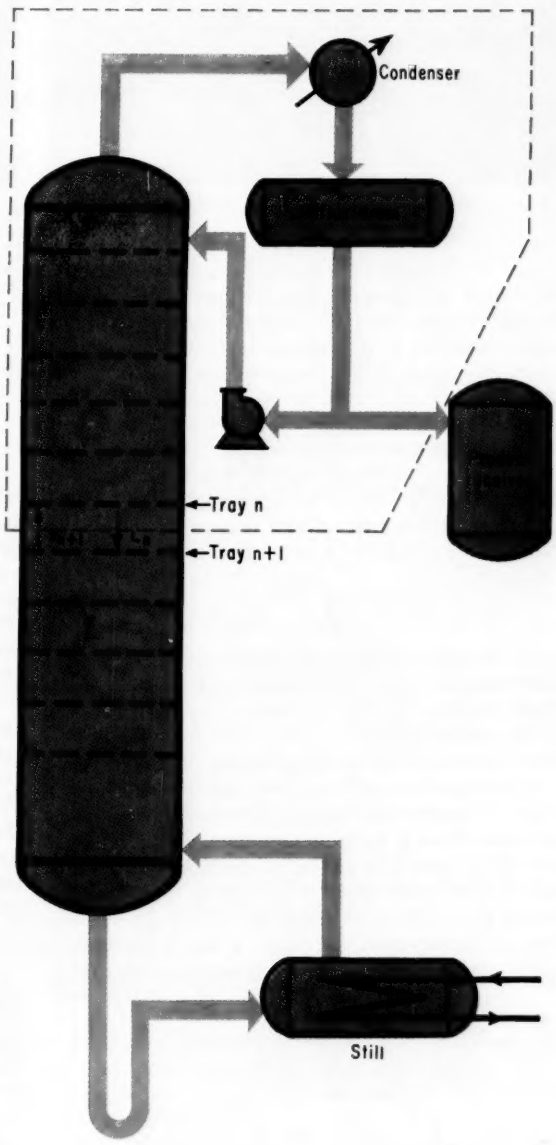
*Louisiana State University*

In our previous article[1] on distillation, we discussed some of the factors that afford opportunity for separation by distillation. For instance, in our example on boiling point calculation, the equilibrium vapor was richer in the more volatile components than was the liquid. On the other hand, the dew point calculation showed that the equilibrium liquid contained higher concentration of the less volatile components than did the vapor from which it was produced.

This difference indicates the possibility of separation of the components of a system by processes in which successive vaporization and condensation are carried out. This may be done by using batchwise or continuous means. In the present article, we will confine our attention to batch distillation.

Batch distillation is often preferable to continuous distillation in cases where relatively small quantities of material are to be handled at irregularly scheduled periods. In many cases, the composition of the material to be separated may vary widely from period to period. Furthermore, in some cases, it is desired to have available a general-purpose still, to be used in handling a number of different products.

The simplest case of batch distillation is one in which the material to be separated is charged to a heated kettle, fitted with a total condenser and product receiver. The material is distilled without reflux until a definite quantity of one of the components of the mixture has been recovered or until a definite change in composition of the still contents has been effected.

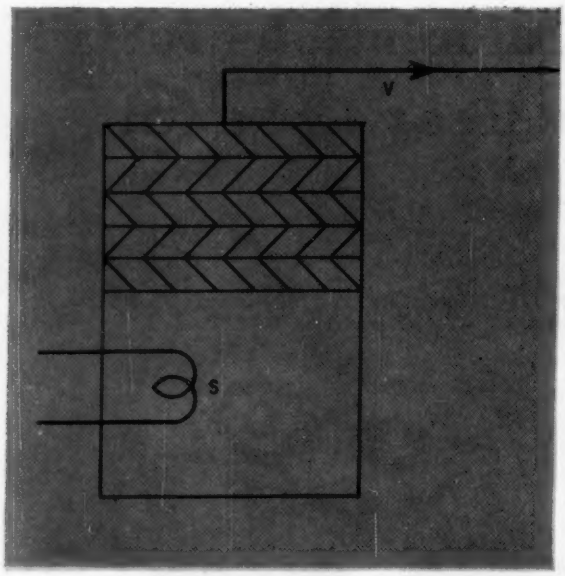



## Equilibrium Batch Differential Distillation

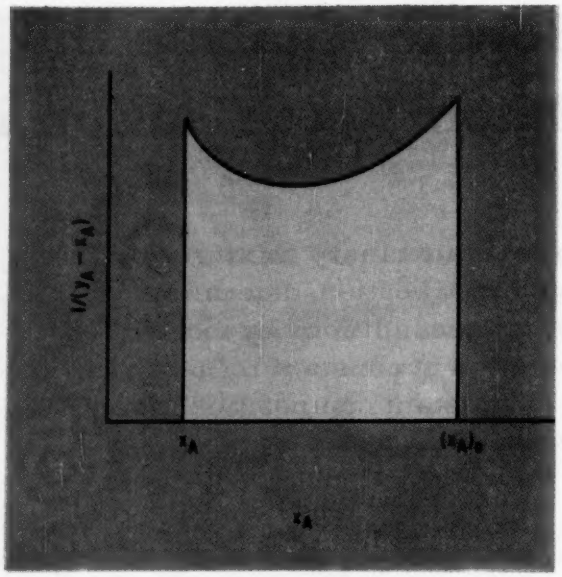
In the device shown in Fig. 1, the shaded areas represent layers of vapor having a differential thickness. The quantity of vapor in each layer is $dV$ and the layers are assumed not to mix at all.

As each layer is removed at the top, it is replaced by another layer of vapor generated from the boiling

**Equilibrium batch-still relations—Fig. 1**




**Integrate Eq. (1) graphically—Fig. 2**




of the liquid in the still. Equilibrium is assumed to exist only between the liquid and the differential layer of vapor adjacent to it. At any instant, the material balances and equilibrium balances are:

$$\begin{aligned} -dS &= dV \\ -d(Sx_A) &= y_A dV \\ Sdx_A + x_A dS &= y_A dS \\ dS(y_A - x_A) &= Sdx_A \end{aligned}$$

Separating variables and integrating, gives:

$$\int_{S_o}^{S} \frac{dS}{S} = \int_{x_A}^{(x_A)_o} \frac{dx_A}{y_A - x_A}$$

$$\ln \frac{S_o}{S} = \int_{x_A}^{(x_A)_o} \frac{dx_A}{y_A - x_A} \qquad (1)$$

where $S_o$ is moles of liquid present in the still when the concentration is $(x_A)_o$ for component A and $S$ is moles of liquid present in the still when the concentration is $x_A$ for component A.

This expression is the well-known Rayleigh equation. Assuming that equilibrium exists between phases, the relation between $y_A$ and $x_A$ for binary systems can be obtained from a temperature-composition diagram and the right hand side of Eq. (1), which is integrated graphically by plotting $1/(y_A - y_A)$ vs. $x_A$. The area as shown in Fig. 2 is the integral.

For multicomponent systems, a more convenient equation can be obtained by using relative volatilities.

$$\begin{aligned} -dl_A &= y_A dV \\ -dl_B &= y_B dV \end{aligned}$$

$$dl_A/dl_B = y_A/y_B = \alpha_{AB} \frac{l_A}{l_B}$$

$$\int_{l_A}^{(l_A)_o} \frac{dl_A}{l_A} = \alpha_{AB} \int_{l_B}^{(l_B)_o} \frac{dl_B}{l_B}$$

$$\ln \left[ \frac{(l_A)_o}{l_A} \right] = \alpha_{AB} \ln \left[ \frac{(l_B)_o}{l_B} \right] \qquad (2)$$

Similarly, for components A and C:

$$\ln \left[ \frac{(l_A)_o}{l_A} \right] = \alpha_{AC} \ln \left[ \frac{(l_C)_o}{l_C} \right] \qquad (2a)$$

A corresponding equation for component A and any other component can be written. Problem 1 shows the application of Eqs. (2) and (2a) to the batch differential distillation of a multicomponent mixture.

*Problem* 1—A mixture consisting of 30 mole % benzene, 40 mole % toluene and 30 mole % o-xylene is charged to a still and then subjected to a batch differential distillation. If 50% of the benzene charged is to be removed by distillation, what percent of the original charge remains in the still at the end of the process? What are the compositions of the residual liquid and the combined overhead product?

Assume that the relative volatilities with respect to toluene are 2.18 for benzene and 0.385 for o-xylene and that these remain constant.

On the basis of 100 moles of original mixture, there remain 15 moles of benzene at the conclusion of the process. Using Eq. (2) and $\alpha_{AB}$ of 2.18, we get:

$$\ln (30/15) = 2.18 \ln (40/l_B)$$

Hence, solving for $l_B$ gives 29.1 moles of toluene remaining.

From benzene-xylene relations, we find $\alpha_{AC}$ equals 2.18/0.385 or 5.67. Substituting in Eq. (2a) gives:

$$\ln (30/15) = 5.67 \ln (30/l_C)$$

Solving for $l_C$ gives 26.55 moles of o-xylene remaining in the residual liquid.

The material balance is summarized as follows:

| | Residual Liquid | | Overhead | |
|---|---|---|---|---|
| | Moles | Mole % | Moles | Mole % |
| Benzene | 15.00 | 20.20 | 15.00 | 51.10 |
| Toluene | 29.10 | 41.20 | 10.90 | 37.15 |
| o-Xylene | 26.55 | 38.60 | 3.45 | 11.75 |
| | 70.65 | 100.00 | 29.35 | 100.00 |

Simple batch differential distillation is not readily adapted to problems in which it is desired to produce a distillate containing a high concentration of the more volatile component, and at the same time to accomplish a high recovery of the more volatile component.

It is a general characteristic of this type of distillation that for a high concentration in the distillate, we must accept a low recovery. If we wish a high recovery, we must do this at the expense of a lowered distillate composition. Of course, if a rather small amount of a highly volatile component were to be removed from a large amount of a component of low volatility, we might obtain a satisfactory recovery and still have a high concentration.

One way to obtain a high degree of separation along with high concentration by simple batch distillation would be to redistill both the residual liquid and the overhead products. This can be accomplished by a multiplicity of simple batch distillations. But this is time consuming, tedious and usually uneconomical. A better way to accomplish separation by batch distillation would be through the use of a batch still with a rectifying column.

## Analyze Batch Rectification

We show a typical batch rectification setup in the drawing on p. 131. In this unit, vapors generated in the kettle pass up the column countercurrently to liquid that is passing down the column. The column must be equipped with a device for securing good contact between the liquid and vapor. Contacting may be effected by means of trays or plates, of which there are a large number of designs, or it may be effected by means of packing.

In this article, we will confine our attention to those devices that contain trays or plates. (These terms will be used interchangeably.)

The performance of packing is often expressed in terms of the number of trays required to give an equivalent separation.

In our previous articles,[4] we have discussed the theoretical tray concept and will use it in this discussion. It will be sufficient here to remember that a theoretical tray is one in which the vapor leaving the tray is in equilibrium with the liquid leaving the tray. In later articles, we will discuss the relation between the performance of actual and theoretical trays.

As the vapor passes up the column, shown in the diagram on p. 131, it passes through layers of liquid held on the trays. This results in a transfer of mass and heat on each tray. Some of the vapor condenses by direct mixing with the liquid and this, in turn, results in the vaporization of a portion of the liquid. In many cases, the sensible heat lost by the vapor in cooling to its dew point is balanced by the sensible heat gained by the liquid in being heated to its boiling point.

For this situation, most of the heat transferred between the two phases, and effective for vaporization, is that due to the latent heat of the components. If the molal latent heats of vaporization of the components are very nearly the same, as is often the case, then the moles of vapor condensed are approximately equal to the moles of liquid vaporized. As a result, the molal vapor upflow from tray to tray remains constant at any instant during the process. Also, the liquid downflow from tray to tray remains constant. In our article, we will assume that this is the case.

Mass is transferred on each tray in such a fashion that the more-volatile components pass from the liquid to the vapor and the less-volatile components pass from the vapor into the liquid phase. Thus, there is an increase in the concentration of the more-volatile components in the vapors as they pass up the column from tray to tray. There is, also, an increase in the concentration of the less-volatile components in the liquid as it passes down the column from tray to tray.

Referring to the drawing on p. 131 a material balance for the section enclosed by dashed line gives:

$$V_{n+1} = L_n + D \tag{3}$$

A balance on any component yields:

$$V_{n+1}\, y_{n+1} = L_n x_n + D x_D$$

$$y_{n+1} = \frac{L_n x_n}{V_{n+1}} + \frac{D x_D}{V_{n+1}} \tag{4}$$

where $V$ is moles of vapor per unit time, $L$ is moles of liquid per unit time, $D$ is moles of distillate per unit time. Subscripts $n$ and $(n + 1)$ designate plate numbers, numbering from the top down.

Eq. (4) is referred to as the operating line equation. It can be rearranged into a number of different forms but the one shown here is all that is required. By the assumption previously cited, Eq. (4) is a straight line at any instant during the distillation.

In batch rectification, we may be faced with the problem of determining the proper conditions for using an existing distillation column with a fixed number of plates or designing a new column in which the selection of the number of plates must be made. In either case, we should consider two modes of operation:

1. Reflux ratio is kept constant. Column has a fixed number of plates and the composition of the overhead product varies.

2. Composition of the overhead product with respect to one of the components is maintained constant. Column has a fixed number of plates and reflux ratio is variable.

## Reflux Ratio Is Constant—Case 1

In this mode of operation, column has a fixed number of plates and operates with constant reflux ratio and variable overhead product composition. Column holdup is negligible.

Rate of depletion of the contents of the still is equal

to the rate of accumulation of the resulting distillate.

$$\frac{-dS}{d\theta} = \frac{dD}{d\theta} \tag{5}$$

where $S$ is moles of mixture in the still at any time $\theta$, $D$ is moles of distillate at time $\theta$.

For any component:

$$-\frac{d(Sx_s)}{d\theta} = \frac{x_D dD}{d\theta} \tag{6}$$

where $x_s$ is mole fraction of component in the still at time $\theta$ and $x_D$ is instantaneous mole fraction of the component in the distillate that is leaving the condenser at time $\theta$.

Combining Eqs. (5) and (6) gives:

$$\frac{dS}{S} = \frac{dx_s}{x_D - x_s}$$

Integrating this equation between indicated limits yields:

$$\int_{S_o}^{S} \frac{dS}{S} = \int_{x_{so}}^{x_s} \frac{dx_s}{x_D - x_s}$$

$$\ln \frac{S}{S_o} = \int^{x_s} \frac{dx_s}{x_D - x_s} \tag{7}$$

where $S_o$ is moles of mixture originally charged to the still and $x_{so}$ is initial mole fraction of the component in the still charge.

Eq. (7) is very similar in form to Eq. (1), the Rayleigh equation previously mentioned. It has been used by Smoker and Rose[2] to estimate batch distillation curves for binary systems in which the mole percent of the more-volatile component in the distillate is plotted against the percent of the charge distilled.

The right hand side of Eq. (7) is integrated graphically by plotting $1/(x_D - x_s)$ vs. $x_s$. The area under such a curve, taken between $x_{so}$ and $x_s$, is the value of the integral.

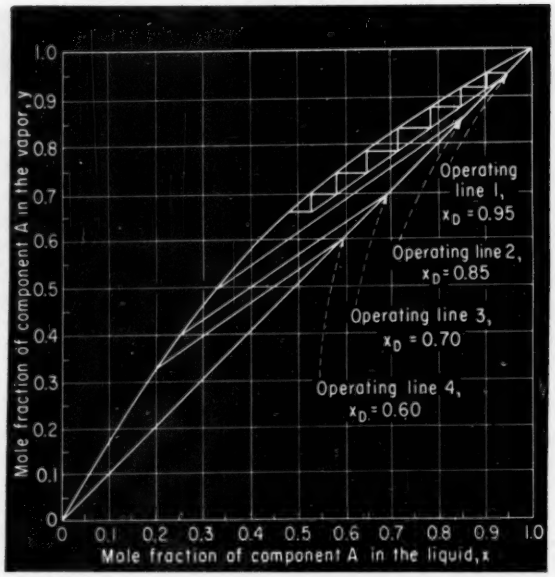
To establish the relation between $x_D$ and $x_s$, the equilibrium diagram is first plotted as shown in Fig. 3. Several values of $x_D$ are selected and operating lines having the same slope ($L/V$ is constant) are drawn through the intersection of $x_D$ and the diagonal. The diagonal line has the equation $y = x$ and operating lines intersect this at $x_D$.

Having drawn these lines, steps are drawn between the operating line and equilibrium line, as in the well-known McCabe-Thiele method. The correct line is that which requires the specified number of theoretical plates. It must be remembered that the kettle will play the same role as a theoretical plate. The intersection of the last horizontal step (going down from the top) with the equilibrium line is the composition $x_s$ of the liquid in the kettle.

Problem 2 illustrates an application of Eq. (7) to this type of batch rectification for a binary system. Also shown in Problem 2 is a comparison of these results with those that would be obtained in a simple batch equilibrium distillation.

Having reduced the still concentration to the desired value, the distillation is stopped. From the over-all material balance and the fact that a constant reflux ratio was used, the total vapor produced by the still for the entire process can be calculated. Since the heat requirement consists mainly of latent heat, the quantity of vapor calculated above can be used to make an estimate of the heat supplied to the still for the process.

## Reflux ratio is constant—Fig. 3




*Problem* 2—A mixture of components A and B, having an initial composition of 48.8 mole % A, is to be separated in a batch rectifying column that contains the equivalent of seven theoretical plates. Ratio of liquid to vapor in the column will be held constant at 0.683 moles of liquid per mole of vapor. Initial distillate composition is to be 95 mole % A. Distillation is to continue until the still composition drops to 19.2 mole % A. Holdup on plates is negligible.

How many moles of mixture per 100 moles of original charge remain in the still at the end of the process? What is the composition of the combined distillate? What percent of component A that was originally charged remains in the distillate? Relative volatility of A with respect to B may be taken as 2.0 and this remains constant.

Construct the equilibrium line by using the following equation with $\alpha = 2.0$:

$$y = \frac{\alpha x}{1 + (\alpha - 1)x}$$

and plot equilibrium line as shown in Fig. 3.

The equation for the operating line is:

$$y_{n+1} = (L/V)x_n + [1 - (L/V)]x_D$$

Using an initial value of $x_D$ of 0.95, we found that an operating line with a slope of 0.683 gave seven theoretical plates when starting at the top and constructing steps downward to the equilibrium line where

vapor leaving the still has the composition $x_s = 0.488$. This construction is shown as Line 1 of Fig. 3. Lines 2, 3 and 4 represent other operating lines, constructed in the same manner, for values of $x_D = 0.85$, 0.70 and 0.60, respectively. In each case, the value of $x_s$ is read on the abscissa at the intersection of the last horizontal line with the equilibrium line. Results are tabulated below:

| $x_D$ | $x_s$ | $x_D - x_s$ |
|---|---|---|
| 0.95 | 0.488 | 0.462 |
| 0.85 | 0.350 | 0.500 |
| 0.70 | 0.245 | 0.455 |
| 0.60 | 0.192 | 0.408 |

The right hand side of Eq. (7) was integrated graphically, and from this value we obtained: $S/S_o$ equal to 0.535. Hence, $S$ equals 53.5 moles per 100 moles of charge. Total distillate is (100 — 53.5) or 46.5 moles.

Component A remaining in the still is:

$$53.5 \times 0.192 = 10.27 \text{ moles}$$

Component A charged is:

$$100 \times 0.488 = 48.8 \text{ moles}$$

Component A in total distillate is:

$$48.8 - 10.27 = 38.53 \text{ moles}$$

Composition of combined distillate is:

$$(38.53/46.5)100 = 82.8 \text{ mole \% A}$$

Percent recovery of A in distillate is:

$$(38.53/48.8)100 = 78.8\%$$

For a constant ratio of $L/V$ and with 46.5 moles of total distillate, $V$ becomes 46.5 moles of vapor per 100 moles charged to the still.

For comparative purposes, if the same percent recovery of component A had been accomplished by batch differential distillation, use of Eq. (2) would show:

$$\ln\left(\frac{48.8}{10.27}\right) = 2.0 \ln\left(\frac{100 - 48.8}{l_B}\right)$$

Hence, $l_B = 23.45$ moles of component B remaining in the still. Moles of mixture $S = 23.45 + 10.27$ or 33.72 moles remaining in the still. Total distillate is (100 — 33.72) or 66.28 moles. Average composition of distillate is [(48.8 — 10.27)/66.28]100 or 58.2 mole % A.

## Overhead Composition Is Constant—Case 2

Column operates with fixed number of theoretical plates, constant overhead product composition and varying reflux ratio. Holdup on the plates is negligible.

Over-all material balance at any time is:

$$S = S_o\left[\frac{x_D - x_{so}}{x_D - x_s}\right] \tag{8}$$

Differentiating with respect to time gives:

$$\frac{dS}{d\theta} = \frac{S_o\,(x_D - x_{so})\,dx_s}{(x_D - x_s)^2 d\theta} \tag{9}$$

We have assumed constant molal vapor upflow and liquid downflow throughout the column at any instant. Accordingly, we can find rate of distillation from:

$$dS/d\theta = (L - V) \tag{10}$$

Substituting in Eq. (9) and solving for the time gives:

$$\theta = \frac{S_o\,(x_D - x_s)}{V} \int_{x_s}^{x_{so}} \frac{dx_s}{\left(1 - \frac{L}{V}\right)\left(x_D - x_s\right)^2} \tag{11}$$

This is the time required for the distillation, exclusive of that required for charging the still, heating up, shutting down and cleaning. Eq. (11) is the same as that of Bogart.[3]

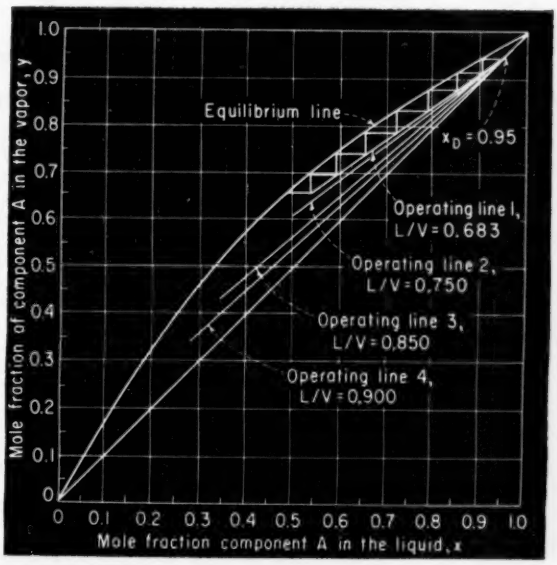
The vapor load $V$, moles/hr., can be calculated if the diameter of the column, estimated allowable vapor velocity, operating pressure and temperature are known. Conversely, if the time were fixed, then the diameter of the column could be calculated using $V$ obtained from Eq. (11).

To evaluate the integral term on the right hand side of Eq. (11), the equilibrium diagram is drawn as before. Several operating lines with different slopes $(L/V)$ are drawn, each passing through $x_D$ on the diagonal.

The steps equivalent to the number of plates and reboiler are drawn in the usual manner for each line. Again, the intersection of the last horizontal step with the equilibrium line gives $x_s$. This is continued until $x_s$ reaches the desired final value. The integral is then evaluated graphically by plotting $1/[1 - (L/V)]$ $[x_D - x_s]^2$ vs. $x_s$ and taking the area under the plot between $x_{so}$ and $x_s$ as before.

In Problem 3, the application of Eq. (11) to batch rectification of a binary system is shown. For comparative purposes, the same initial charge and final still concentration as used in Problem 2 is used in

## Reflux ratio is variable—Fig. 4



Problem 3. For this type of operation, the heat load on the still can be estimated by using $V$ from Eq. (11).

The minimum number of plates possible is that obtained when operating at total reflux between the specified $x_D$ and the final still composition. The number of plates actually used must be greater than this minimum.

*Problem 3*—A mixture of components $A$ and $B$, having the same initial compositions and relative volatility as that of Problem 2, is to be separated by batch fractionation into a distillate that contains 95 mole % $A$. The column for this distillation contains the equivalent of seven theoretical plates. Time allowed for distillation is to be 1 hr./100 moles of original charge, exclusive of the time required for charging, warming up, shutting down and cleaning. The distillation is stopped when the still composition drops to 19.2 mole % $A$.

How many moles of distillate of the specified composition are produced? What percent of the $A$ originally charged to the still is recovered in the distillate? How many moles of vapor per hour must be generated in the still?

The equilibrium line is the same as that for Problem 2. Use $\theta = 1$ hr. and $S_o = 100$ moles. From Eq. (11), we calculate the number of moles of vapor per hour generated in the still.

On Fig. 4, operating lines 1, 2, 3 and 4 are plotted for values of $L/V$ of 0.683, 0.75, 0.85 and 0.90, respectively. All operating lines pass through point $x_D$, equal to 0.95, on the diagonal. Each operating line is for a column containing the still and seven theoretical plates.

In each case, the value of $x_s$ is read on the abscissa at the intersection of the lowest horizontal step and the equilibrium line. Results are tabulated below:

| $L/V$ | $x_s$ | $(x_D - x_s)$ |
|---|---|---|
| 0.683 | 0.488 | 0.462 |
| 0.750 | 0.440 | 0.510 |
| 0.850 | 0.278 | 0.672 |
| 0.900 | 0.210 | 0.740 |
| 0.917 | 0.192 | 0.758 |

Using the above data, graphical integration between the limits 0.488 and 0.192 was performed for the expression:

$$\int_{x_{s_o}}^{x_s} \frac{dx_s}{\left(1 - \frac{L}{V}\right)\left(x_D - x_s\right)^2} = 4.63$$

Substituting in Eq. (11) gives:

$$V = \frac{100\,(0.95 - 0.488)}{1.0} \times 4.63 = 213.5 \text{ moles/hr.}$$

Over-all material balance gives moles remaining in still* as:

$$S = 100\left[\frac{0.95 - 0.488}{0.95 - 0.192}\right] = 60.8 \text{ moles}$$

Total distillate* is:

$$100 - 60.8 = 30.2 \text{ moles}$$

* These answers are obtained without reference to Eq. (11).



Percent recovery* of $A$ in distillate is:

$$\left[\frac{39.2 \times 0.95}{48.8}\right] 100 = 76.2\%$$

## Compare the Methods of Operation

In simple batch distillation, the overhead product purity is low for a high recovery. A high purity is obtained at the expense of a low recovery of the desired component in the distillate.

Use of batch rectification employing the Case 1 method of operation greatly enhances both overhead product purity and the percent recovery of the desired component in the overhead product when compared with simple batch distillation. Also in this case, increased product purity will be accompanied by decreased percent recovery.

Where batch rectification is carried out in accordance with the system described in Case 2, it is possible to produce a specification product. However, the percent recovery of the desired component in the overhead product may be less than in Case 1 for the same final still composition. Final choice between these methods of operation is made from economic considerations that are beyond the scope of this article.

### Nomenclature

| | |
|---|---|
| $l$ | Moles of individual component in liquid. |
| $S$ | Total moles of liquid in the still at any time. |
| $x$ | Mole fraction of component in liquid phase. |
| $y$ | Mole fraction of component in vapor phase. |
| $\alpha_{AB}$ | Relative volatility of component $A$ with respect to component $B$. |
| $\alpha_{AC}$ | Relative volatility of component $A$ with respect to component $C$. |

**Subscripts**

| | |
|---|---|
| $A, B, C$, etc. | Components in mixture. |
| $o$ | Designates initial quantity. |

### References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3. Bogart, M. J. P., *Trans. AIChE*, 33, 139 (1937).
4. Coates, J. and B. S. Pressburg, *Chem. Eng.*, Sept. 5, 1960, p. 140; Oct. 3, 1960, pp. 99-104; Oct. 31, 1960, pp. 109-114.

*In November at Kansas City,* Chemical Engineering *and Midwest Research Institute sponsored a two-day technical conference to re-emphasize the fundamental importance of chemistry, mathematics and physics in chemical engineering. It called attention to techniques based on these sciences that are beginning to find application in our field. At this conference, ten papers were presented covering The New Tools of Engineering, The New Mathematics and The New Chemistry. There were two of these papers in our Dec. 12, 1960 issue, two in Dec. 26, and three in the Jan. 9, 1961 issue. The remaining papers appear in this issue.*

# Operations Research: A Progress Report

***Having gone from one extreme to the other—"big minds working on small problems" to the panacea for everything—operations research is now coming of age and proving to be a valuable management tool in many industrial and nonindustrial areas.***

JAMES C. HETRICK
*Arthur D. Little, Inc.*

A progress report on industrial operations research today might well begin by citing factual data from two 1957 surveys. The AMA questioned 3,150 companies, of which 20% responded. Of these, 10.5% use OR, 4.4% are considering such an activity and 5.1% do not intend to use OR methodology.

Not one of the companies reporting the use of operations research intended to discontinue the program. Of the 234 companies commenting on future plans, only two indicated an intention to reduce the rate of activity, and 95 contemplated no change until the existing program could be evaluated.

The users of OR are diverse, including 65 manufacturers of chemicals, petroleum and allied products; 51 of electrical machinery and electronic products; 44 of non-electrical machinery, including automobiles; 33 of miscellaneous products. Penetration varies from virtual saturation (19 companies out of 23) in the aircraft industry to only one third of the reporting companies in the financial institutions, including banking and insurance. (This group also had the largest proportion of those not intending to use operations research.)

The size of OR groups varies from an average of three in the food industries to 20 in aircraft, with a grand average between six and seven for all industry. But the groups were relatively homogeneous in training, 85% being physical scientists (including engineers, mathematicians, and statisticians), the remaining 15% social scientists, geographers, meteorologists and accountants.

Of these companies, 57% found these personnel within, the remainder being secured equally from other companies and from universities. Only 40% of the companies used internal training programs, the rest relying on university courses and consultants. Only 39% failed to use consultants, with the overwhelming majority of the remainder using mixed teams of consultants and their own people.

The OR function is, in general, organized at relatively high levels. In 65 cases, the groups report either to the president or to "top management." In another 144 organizations, the group reports to a vice president—operations, production, manufacturing, or finance. In 40 other companies, operations research is under the chief industrial engineer or someone of equal rank.

The remaining firms put their OR groups under the treasurer, the controller, the director of research or of market research, the chief engineer, or a manager of operations research or operations analysis.

Two hundred and eleven companies reported the areas in which they are using OR techniques. Production was cited as an area of application by 72% of the organizations—it was the most important in all categories of industry except aircraft, transportation, utilities and finance. Sales, marketing and inventory problems were those fields next most frequently mentioned.

However, 211 companies said they were using OR to attack long-range planning problems. At the time of the survey, OR seemed to be only getting under

way in such areas as accounting, advertising, purchasing, transportation and shipping, although since 1957, some very interesting work has been done in these fields. At the same time, the National Industrial Conference Board produced the list of problems shown on p. 139 that have been studied by OR:

Two hundred and eighty-eight companies offered evaluations of their operations research program. Improved operations were reported largely by utilities, aircraft and transportation companies.

Dollar savings were reported by only a few companies, but in those reporting, the amounts were significant: 17 companies reported actual savings of over $100,000; five companies reported actual savings of over $1,000,000; and two companies reported actual savings of over $2,000,000.

Anticipated savings of $100,000 were indicated by 23 companies, of $300,000 were indicated by 18 companies, and of $1,000,000 were indicated by five companies.

Many replies emphasized that dollar savings were only a small part of the gain to be expected, with a larger part being reflected in management's more realistic approach to decisions.

Not all respondents were equally enthusiastic about operations research. While only a few indicated negative reactions towards OR, some did so strongly. Several were skeptical about the value of operations research to the smaller company. But, on the whole, the survey respondents were quite favorably inclined toward OR.

Much of the work reported has referred to solution of day-to-day operating problems; but the maturing discipline is tending to pay more attention to basic problems of strategic rather than tactical importance. This effort has been notable principally in the process industries, and case histories of recent work are interesting from this viewpoint.

## Ceramic Formulation by "Grasshopper" Technique

Research programs in the physical sciences usually involve a series of research cycles. Each cycle involves a review of existing information, the development of new ideas based on the information and laboratory testing of these new ideas to yield still more information.

In a successful research program, these cycles serve first to clarify the problem; next, to develop understanding in more and more detailed form; and finally, to develop an answer to the problem. We can say that successful research converges on the answer to the research problem.

A ceramics manufacturer wanted to develop a cheaper product having satisfactory physical properties. There were five properties of interest: cofficient of expansion, opacity, corrosion resistance, surface, and high-temperature fluidity. There were 15 raw materials available for compounding the ceramic formulations. Relationship between composition and properties was largely unknown.

The OR team developed a method, the "Grasshopper" technique, to improve the speed of convergence of research efforts aimed at product or process improvement.

There are essentially five steps involved in this technique that, although related, have sufficiently distinct objectives to justify separate consideration. Each of these steps involves a different kind of activity: clerical, scientific, mathematical-statistical, computational and experimental.

### Step 1: Clerical Work

The available information is collected in a form that is both comprehensive and useful—files of IBM cards or, better yet, files of magnetic tape. Although a considerable amount of clerical work is required to get the information into a consistent and well-defined format, the value of the existing information is much enhanced because its accessibility is very much improved.

### Step 2: Scientific Work

We utilize as fully as possible all available opinion on the form of the relationships to be expected among the characteristics of interest, the formulation, and the treatment variables that can be controlled. Many of the most useful functions arose from the scientific and technical insights of the people working experimentally in the field under investigation.

### Step 3: Mathematical Work

When the existing experimental data have been organized and the product or process has been characterized, the mathematical-statistical task of relating product or process characteristics to formulation and processing variables can begin. The purpose of work in this phase is to develop accurate equations and to assess their precision.

The *accuracy* of the equations will depend on the scientific work accomplished in Step 2, while the *precision* of the equations, and hence their usefulness in describing the phenomena of interest, will depend on the amount and "spacing" of the experimental data gathered together in Step 1.

### Step 4: Computational Work

We use this information to simulate the results of laboratory or plant research work on a digital computer. The computer is programmed to investigate a number of different product formulations and to calculate for each one a measure of experimental desira-

bility. The name "Grasshopper" for the over-all program comes from the inclusion of a random element in the choice of product formulations to be examined—the computer hops from formulation to formulation. The result of this simulation is a list of experiments in decreasing order of desirability, so that expensive experimental work can be focused in the most promising areas.

The measure of experimental desirability is chosen so that experiments are most likely to be performed in areas where a modest improvement is most probable or in regions where previous experiments do not exist but where a significant improvement is predicted.

## Step 5: Experimental Work

The final step in an experimental cycle is to perform the laboratory or plant experiments developed by the computational work. These experiments are certain to be useful because of the way they have been chosen. They will lead either to an improved product or process, or will provide essentially new experimental information, or both. When a sufficient number of new experiments has been performed, the entire cycle can be repeated. Each new cycle should lead to improvement in all of the steps with a resulting convergence to the best product formulation.

In this case, six equations were developed, each of which related a physical characteristic of the ceramic (including cost as one characteristic) to particular functions of the elements included in the ceramic formulation. The mathematical form of the functions that were considered for inclusion in these equations was based on the knowledge and insights of experienced chemists and ceramicists.

Statistical techniques were then used to choose the "best" functions from those proposed—those that most effectively explained the existing experimental data—and to calculate values for all undetermined constants.

The resulting equations were then used on a computer to search for lower-cost formulations. Laboratory tests were used to verify the computed predictions. Significantly lower-cost formulations were found as predicted. In addition, an opaque formulation was predicted and verified in a region previously thought to yield ceramics unsatisfactory in this regard.

The same technique has been applied to development of a product with an increased operating life; and it seems applicable to many similar problems, as in alloy products. Such techniques, and similar work such as that of G. E. Box and Kiefer-Wolfowitz are important contributions to the body of knowledge that comprises the science of operations research today and to its continued future development.

Although not so neat as such formal algorithms as linear programming, these methods of statistical exploration of response surfaces bid well to become basic tools for decision.

## Where operations research was useful

Analysis of the operations of a railroad classification yard.

*Production and inventory control in a chemical process.*

Control and distribution of cash in a decentralized bank.

*Influence of vehicular speed and spacing on tunnel capacity.*

Improved program of personal loan collection.

*Mathematical models for freely flowing highway traffic.*

Purchase versus storage of gas to meet seasonal requirements.

*Use of storage water in a hydroelectric system.*

Proposal for revision of New York's subway fare structure.

*Determining future office space requirements.*

Strip mining phosphate rock with large walking draglines.

*Empty box car distribution.*

Effect of night openings on department store sales.

*Improved rail replacement program.*

Effect of promotional effort on sales.

*Optimal estimation of executive compensation by linear programming.*

Mathematical programming of portfolio selection (investments).

*Traffic delay at toll booths.*

## Determination of Bulk Storage Requirements

Nine different starch-producing units in two plants of a large starch manufacturer make more than 350 different types of starches. Certain starches can be made only at certain units, and different ones have differing production rates as well as other processing difficulties.

In these operations, it is desirable to improve customer service, reduce inventory costs (historically, inventory has always been in bags, and a significant portion is in rented warehouses), and reduce product-change (setup) costs.

Bulk storage for three of the nine production units appeared an attractive possibility. These three units feed directly into a single packing station. Product packed in bags not destined for immediate customer shipment is delivered from the packing station into inventory, either in an internal plant warehouse or in external rented warehouse facilities.

The advantages of bulk storage appeared to be as follows:

1. Reduction in inventory and setup costs.

2. Reduction in costs of reprocessing bags damaged in warehousing, and costs of unmerchantable product.

3. Almost complete elimination of odd-lot batches (those too small for shipment) and associated costs.

4. Reduction, assuming proper design, in the amount of time required to analyze products chemically, thus helping move toward the goal of improved service.

Physical bulk-storage installation would be located between the three production units and the single packing station. It was hoped that external warehousing would be eliminated through the use of the bulk-storage facility and that, in addition, some internal warehouse space would be made available.

### The Graphite and Cellulose Method

An OR team was assigned to determine how much justification there was for bulk storage, how many bulk units would be required, and of what size. The team decided to study sales for these units during the 18-month period from October 1957 to March 1959 and to simulate a bulk-storage system that would satisfy the actual sales requirements during this period —that is, to determine on paper which bulk-storage system would best meet actual sales requirements.

The following information was necessary for the simulation:

1. Basic bulk starch codes—in view of the manufacturing specifications and other processing differences and similarities between product codes.

2. The processing facilities required *after* the installation of the bulk starch units to produce the balance of the product codes. (A product code is a single, salable item. Several product codes can be produced from one bulk starch code. It was determined that 85% of the finished-product codes could be produced from a limited number of bulk units.)

3. Daily sales by product code for the 18-month period, coded to the appropriate bulk starch units.

4. Customer and manufacturing lead-time history on orders.

5. History of back orders caused by "out of specification" conditions, mechanical failure of equipment, and so forth.

6. Manufacturing and inventory costs, and economic production lot sizes in terms of bulk starch units.

A program for a small computer, simulating the operation of the plant, included such real factors as the probability of a batch of product being off specification and subject to reprocessing.

### Computer Simulates a System

For each of the 78 weeks in the simulation period, the computer read in orders for a full week and performed the required internal computations. It then typed out the week number, production and inventories at the end of each week for the production units as a whole and for each bulk group, the available inventory at the beginning of the week, the production delivered during the week, and the actual inventory at the end of the week.

The sales and the range of inventory levels for each bulk group were plotted and an actual bulk-group size design formula developed. This formula gives the bulk-storage capacity requirements under a variety of conditions and for starch production units other than the three studied.

From a study of the print-out and the over-all simulation, together with the design formula, the number of bulk units required was determined and various bulk-unit sizes were calculated for each assumed level of customer service.

### Benefits of the Study

Tangible savings were indicated in the following areas:

1. Inventory: Rented warehouse space eliminated, and 30,000 sq. ft. of plant warehouse space freed for other uses.

2. Setup costs: Product changes significantly reduced.

3. Reprocessing costs: Amount of unmerchantable product, damaged bags, odd lots, and bags that exceed shelf-life, reduced.

4. Labor: Manufacturing and warehousing labor cut.

The total annual savings in these four areas equaled $669,700.

The intangible savings indicated were improvement in the following areas:

1. Customer service.

2. Uniformity of product quality.

3. Efficiency and productivity of supervisory and warehouse personnel.

4. Housekeeping.

5. Raw starch supply for other finishing departments (a source of real dollar savings, but extremely difficult to evaluate).

6. Operation of the production warehouse, including the elimination of unnecessary phone calls and many other sources of confusion and irritation.

### Unexpected Benefits, Too

In addition to the tangible and intangible savings, some other unexpected benefits were indicated by the study. First, it became apparent that simulation provided the tools to develop formal production-scheduling rules for both bag and bulk storage operation.

Second, the design formula showed that bulk storage capacity requirements varied, not as sales, but as the square root of sales. Guided by this relationship, the product codes were re-assigned into new quality groups, thus reducing the over-all storage requirements by 22% and also effecting substantial installation-cost savings.

Third, the computer program, with modification, could be used for future verification of packing-equipment design—specifically to determine what packing and take-away facilities would be required to handle the daily sales demand of the many individual product codes.

## How to use the grasshopper technique

A manufacturer of wire wished to prepare 30-gage wire from copper, nickel and aluminum having as low a resistance as possible, but with a tensile strength of at least 70 kg./mm². In coordination with the company's scientific personnel, the following equations were developed to express in functional form the general effect of different combinations of the ingredients on resistance and tensile strength:

$$r = b_1c + b_2a + b_3 \max(a, 1.9n) \quad (1)$$

$$t = b_4(1 - e^{-b_5 c}) + b_6 a + b_7\sqrt{n} \quad (2)$$

where

$r$ = resistance in ohms/m.
$t$ = tensile strength in kg./mm².
$c$ = percentage copper in wire.
$a$ = percentage aluminum in wire.
$n$ = percentage nickel in wire.

and $b_1$, $b_2$, $b_3$, $b_4$, $b_5$, $b_6$ and $b_7$ are constants.

Information gathered from previous experiments about the interaction of the component metals was put on punched cards. These data were then used by a computer in a regression analysis to determine the following values for the constants: $b_1 = 0.532$, $b_2 = 0.646$, $b_3 = 0.44$, $b_4 = 28.0$, $b_5 = 0.033$, $b_6 = 0.58$ and $b_7 = 6.7$

The expressions

$$100 = c + a + n \quad (3)$$

$$r = 0.532c + 0.646a + 0.44 \max(a, 1.9n) \quad (4)$$

$$t = 28.0(1 - e^{-0.033c}) + 0.58a + 6.7\sqrt{n} \quad (5)$$

$$70 \leqq t \quad (6)$$

were then used to simulate the results of research work. A program to test different combinations of $c$, $a$ and $n$ was prepared for a digital computer. Starting with given values $c$, $a$ and $n$, a random deviation was selected for alternate compositions. In this case, such a deviation was chosen by selecting two random numbers, and $r_1$ and $r_2$ from a normally distributed set with mean zero and standard deviation one.

These numbers were then multiplied by scaling factors $d_1$ and $d_2$ to obtain one trial deviation for $c$ and $n$. Another was obtained by multiplying $r_1$ and $r_2$ by $-d_1$ and $-d_2$. The mathematical expressions were then evaluated to see if any improvement resulted. If so, it was used as a starting point for subsequent trial deviations.

In the application above, the values $d_1 = 5$ and $d_2 = 3$ were used. Starting with $c = 40$, $n = 30$ and $a = 30$, the results shown in Table I were obtained.

With the starting values given in Trial 1, improvements were obtained in Trials 2, 4 and 6.

These, and the results of other trials, indicated combinations of ingredients that might give promising results. Experimentation in the laboratory proved certain of the combinations to be satisfactory improvements. With these new laboratory data, another regression analysis was done to obtain new mathematical expressions, and the process of trial evaluation and laboratory experiments was therefore repeated.

### Results of sequential grasshopper trials—Table I

| Trial | $r_1$ | $r_2$ | $c$ | $n$ | $a$ | $r$ | $t$ | Comments |
|---|---|---|---|---|---|---|---|---|
| 1. | — | — | 40 | 30 | 30 | 64.4 | 74.6 | starting values |
| 2. | 0.464 | 0.137 | 43.32 | 30.41 | 27.27 | 63.8 | 73.9 | improvement, new basis |
| | | | 37.68 | 29.59 | 32.73 | 64.8 | 75.3 | no improvement |
| 3. | 2.455 | −0.323 | 54.60 | 29.45 | 15.95 | 61.6 | 68.95 | improvement, but $t \geqq 70$ not satisfied |
| | | | 30.04 | 31.37 | 38.59 | 65.5 | 78.0 | no improvement |
| 4. | −1.334 | 1.278 | 35.65 | 34.23 | 30.12 | 65.2 | 76.3 | no improvement |
| | | | 48.99 | 26.59 | 24.42 | 63.3 | 71.2 | improvement, new basis |
| 5. | −0.482 | 1.677 | 46.57 | 31.63 | 21.80 | 63.5 | 72.3 | no improvement |
| | | | 51.41 | 21.55 | 27.04 | 61.7 | 69.4 | improvement, but $t \geqq 70$ not satisfied |
| 6. | 1.046 | −0.508 | 54.22 | 25.07 | 20.71 | 61.8 | 70.3 | improvement, new basis |
| | | | 43.76 | 28.11 | 28.13 | 63.4 | 73.2 | no improvement |

The techniques of simulation have been viewed by many as far from satisfactory, and even dangerous. And so it may be in many cases. But OR has survived the early "gimmick" or "bag of tools" approach and has stopped looking for the magic formula that solves all problems.

Simulation technique can provide analogs for complex operating systems and means of analysis of the systems' response characteristics. When combined with statistical design techniques by using these latter to select parameter values for the simulation, we have a potent tool if properly applied.

The term "simulation" might even be broadened to include the large-scale study of dynamic systems that

can be analytically studied and optimized for any static configuration of the system. An example of such a study follows.

### Programming Capital Investment

A study in scheduling capital investment, representing a very significant advance in engineering decision-making can be illustrated by a case concerning an oil refinery that, while physically adequate, was technologically obsolete.

At the time of the study, high-octane blending stocks were being brought in to upgrade the refinery output to an acceptable level. The refinery could be modernized at the cost of additional capital investment in refining equipment; or it could be scrapped and the area supplied from elsewhere at the cost of additional capital for pipelines or higher transportation costs.

The question was defined broadly as being how best to supply the entire region over the long term. The refinery in question was considered variously as being shutdown, modernized at its existent capacity, and at three practicable levels of expansion.

Two additional modern refineries were considered variously at present crude rates, enlarged by bottleneck removal, and with a further 25,000-bbl. expansion. Additional facilities to meet predicted octane levels were included in each plant as required. Year by year estimates for market demands for the total area to be served by the three refineries were prepared, based in general upon normal growth but with accelerated growth in certain metropolitan and coastal areas in selected years.

Consideration was also given to the continuance or termination of large-volume bulk sales to marketing companies. Alternative pipeline, exchange, and purchase possibilities were incorporated.

By taking into consideration market demands for both bulk and branded sales for the 10-year period 1958 through 1967, and a host of other data including those pertaining to transportation and trans-shipment, the optimal pattern for supplying the area was determined for each combination of refineries both with and without pipelines.

### Computers Need Guidance

Each combination of refineries, pipelines and exchanges constitutes a case, and in all more than two hundred cases were considered, each one representing a quite complex model. When the results were evaluated, it turned out that the optimal solution required immediate modernization of the obsolete refinery, operating it through 1961, placing it on a stand-by basis from 1962 through 1964, and re-opening it in 1965 after having expanded it.

This was disconcerting.

Although it represents a true optimum, it is an impractical one because, although a refinery might be held on stand-by for several years the people involved cannot be.

Consequently, a number of alternatives were examined—comparing operating costs, cumulative increase in operating costs relative to the unfeasible optimal solution and cumulative increase in operating capital on a year-by-year basis. The various alternatives were ranked in the order of their desirability.

It was possible to show that the best feasible plan —having a higher rate of return and a considerably lower investment—was considerably better than the next best of four practical "grand strategies." Such data indicate the importance of results obtained from good guidance of investment scheduling.

This example illustrates, among other things, the importance of human intervention. Left to its own devices, the computer would have adopted an unworkable scheme involving a stand-by refinery expected to start up after several years of idleness. Computers can be programmed to make certain kinds of decisions, but only when a human being works out the principles and sets the computer up to perform automatic decisions obeying those principles.

In presenting case histories, it is easy to present only "big" problems—representing important decisions and massive offorts. All of the three cases discussed were truly large, requiring many months of work and many hours of high speed computing. It is important that the research approach is equally valid for the quick decision, with minimal effort.

Operations research is, essentially, quite a simple concept. It boils down to little more than having in hand all the facts about a situation and making a choice among one of several possible decisions based on those facts. It requires judgment and it requires information. Big, complex problems require computers and sophisticated techniques for their solution, but small problems are more easily solved.

### Assignment to Rotating Shifts

During the annual contract renewal negotiations, a management was unexpectedly faced with the union's demand for major changes in permissible rules for assignment of personnel to rotating shifts on a continuous operation. So unexpected were the demands, that negotiations were suspended while management put the question to the OR group—not, "How much will it cost?" but "Is it possible to schedule operations and meet these requirements?"

In the assignment of personnel to operations that are carried on continuously, difficulties arise in making a schedule that is fair to both management and labor. One difficulty arises from the relationship between the 40-hr. work week and the 168-hr. week, so that 4.2 men must be assigned for each man required in continuous operation. Thus, a "progression group" for a job requiring one man must actually contain five men, the fifth man working one fifth of the time as an operator on the job under discussion, and being assigned four fifths of the time as a laborer.

The progression group for a two-man assignment must consist of nine men, the ninth man being assigned three fifths time as a laborer, and so on. Only in

groups for assignments requiring a multiple of five men can all men be assigned full-time as operators, but this desirable arrangement is not always possible—may, in fact, be quite impossible in many such situations.

Within the progression group, it is desirable that the progression be such that (a) the same number of days is worked in each pay period, (b) for men with operator-laborer ratings, the same number of days is worked in each capacity in each week, (c) each man works an approximately equal number of times on each shift.

It was further required in then current negotiations that a man's schedule be such that in no case would he receive an isolated day off; that at least five days be worked in every week; that changes in shift be always in the order "A" shift to "C" shift, "C" shift to "B" shift, and "B" shift to "A" shift; and that a shift change allowing less than 16 hr. between working periods be compensated for by double pay for the second period.

This solution required no massive effort—the problem was presented at 4:00 p.m. one afternoon; the solution—a schedule meeting all requirements—was produced at 11:00 a.m. the next day, by one man using paper and pencil.

## Where We Are Today

Operations research is, today, a real factor in the business world. It takes its proper place as one of the supporting service activities—such as industrial engineering, market research, accounting and statistical services—which in the last half century have been acquired by management to provide analytical support for decision-making. It has lost the naivete of its early years, when picturesque techniques such as linear programming, game theory, and Monte Carlo methods were widely touted as *the* answers to management problems.

The profession now accepts particular techniques more soberly and tends to return to basics and develop new tools as needed. Similarly, it has survived the middle years, when OR was called with some justice "the application of big minds to small problems."

During this time, there was a real and dangerous tendency to turn inward and supply more and more exact solutions to increasingly narrow problems. OR now stands as one of the management sciences and may mature as a cohesive agency among them. These thoughts have been excellently expressed by Ernst and Magee:

"Operations research, in fact, has had a shock effect on other business services and business training. The reaction in many cases, notably within industrial engineering, is evident in the greater emphasis on broader training in method. The effect is evident in business training, where new emphasis is being placed on statistics, systems analysis and mathematics. It is still too early to tell what the effect will be. It may conceivably lead to other business functional services or professions reclaiming their role of analysis within their functions, and much of the field of tactical studies in operations research may be subsumed under reinvigorated functional services.

## The Future of Operations Research

"What will be the effect on operations research as a profession? If other services respond to the challenge, OR might well disappear. After all, much of the growth of OR to date in industry has resulted from the void left by existing services in their concentration technique, and their failure as a result to meet new managerial needs created by the changing post-World War II business environment. Operations research, on the other hand, might increasingly assume the role of a general management service; however strong functional service may be, there still remain problems of integration and balance, and the problems of the whole business as a system.

"Another most likely effect, we feel, would be that operations research will develop less as a unified profession than as a rallying point, a point of common interest among functional professional groups. To some extent, the Operations Research Society of America performs in this manner now. If the functional services, such as industrial engineering or marketing, develop strong experimental and theoretical capabilities, the opportunity may exist for a true multidisciplinary attack on business system problems."

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Meet the Author

*JAMES C. HETRICK has been a senior staff member at Arthur D. Little, Inc., Cambridge, Mass., since 1957. Here he has worked on a variety of problems involving operations research such as capital facilities planning, research on research, a variety of computer simulations and others.*

*Prior to joining ADL, Mr. Hetrick spent three years as supervisory research scientist in charge of the operations research and computer group at Continental Oil Co. and five years with Ethyl Corp. in similar capacities.*

*Our author has been chairman of the Computer Panel of the Industrial Mathematics Society, member of the Advisory Committee, Wayne University Computation Laboratory, and visiting professor in the Graduate School, Oklahoma State University.*

*Mr. Hetrick received his B. Sc. and M. Sc. in physical chemistry from the Philadelphia College of Pharmacy and the University of Delaware, respectively, and saw Army service in World War II.*

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**What are the ways that chemistry can help in attacking problems of interest to the chemical engineer? A chemist outlines what's "new."**

# A Survey of the New Chemistry

NORMAN HACKERMAN, *University of Texas*

It's necessary to recognize that there has been no basic change in the character of the science of chemistry. Basically, of course, chemistry remains a study of the groupings of atoms that are in sufficiently stable arrangements to make themselves evident in some fashion.

Chemistry continues to be concerned with knowing and understanding the physical and chemical properties of these units. This provides predictability with respect to reactions and material properties for the chemical engineer.

If "new" is not limited too strictly to its most literal meaning, the outstanding new aspect of the field is the major role of the theoretical approach in dealing with research problems. The theoretical point of view is concerned primarily with discerning from first principles the nature of the forces holding the atoms in a given unit. This requires imagining, in as much detail as possible, the several types of repulsive and attractive interactions and fashioning from them certain implicit equations.

Generally, it is not possible to convert these equations into explicit form since the appropriate mathematics often is not available. However, with reasonable assumptions, some quantitative relationships are possible for the simplest systems.

Even though this approach is not literally translatable to more complex systems, it does have both prognostic and diagnostic values in such cases, when applied with care and good sense. In other words, it permits less-sophisticated treatment of more commonly encountered systems, and makes possible the rationalization of some experimental results. Furthermore, it gives rise to ideas for new experiments.

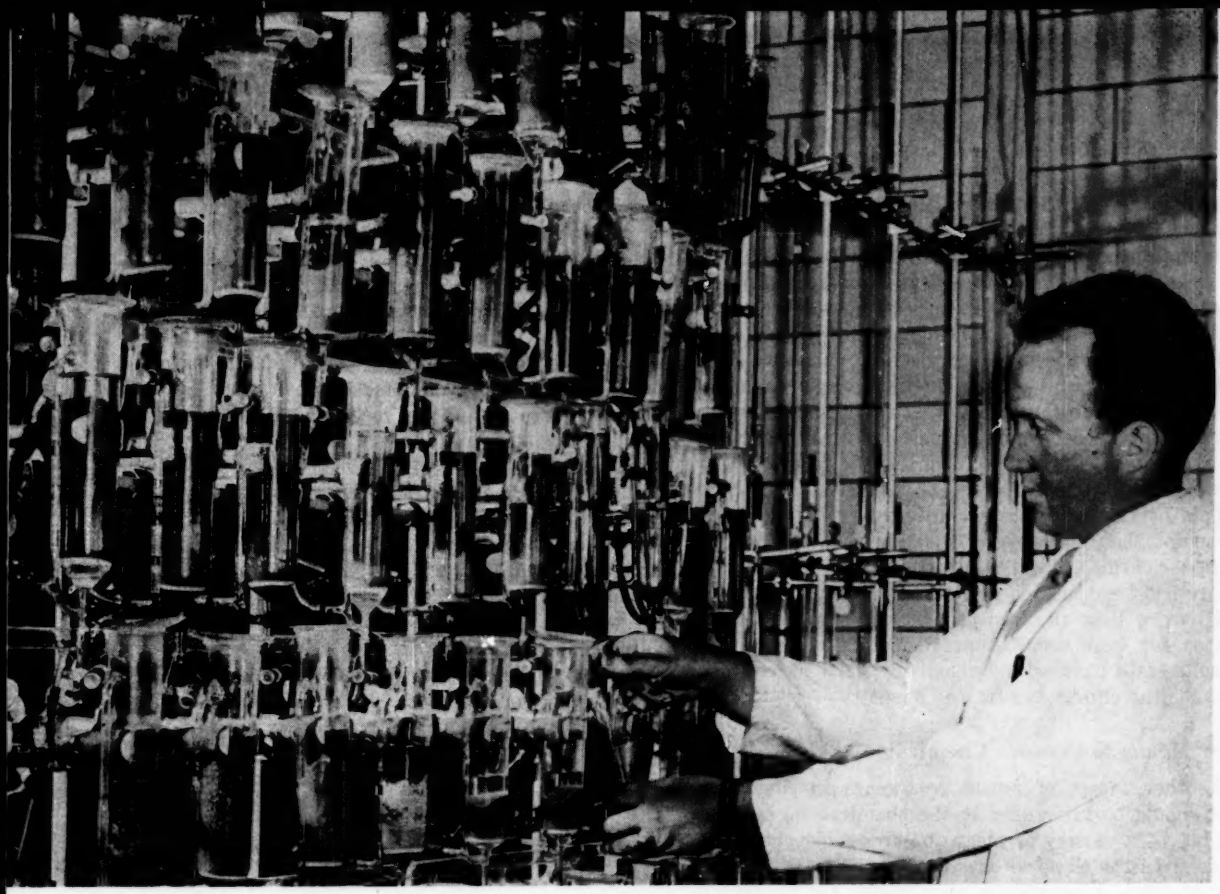
More and more, chemists have come to the use of an all-molecule concept of atom groupings as a possible replacement for the older and more familiar valence-bond idea. There is a clearer visualization of molecular entities, of intramolecular spatial relationships and of electrons of nonlocalized character belonging to the molecule as a whole—perhaps describable as being "nationalized."

Inevitably, the arrangements and the forces causing these arrangements hold the clues to the means and rates of transformation into other atom groupings. In this connection, it is worth pointing out that an infinite variety of atom groupings is possible, and we are concerned with those that are not so transitory that they cannot be observed directly or by instrument. This simply means that stability is not an absolute quality.

Methods now available for following very fast reactions make it possible to observe some groupings formerly only guessed at, or even totally unimagined. Shock tubes, the linear electron accelerator, time-of-flight instruments and high-frequency alternating-current electrolysis are all examples of such devices and techniques. An interesting reference to this field is *Discussions Faraday Soc.*, **17** (1954) on "Study of Fast Reactions."

Before getting too far from the subject of the theoretical chemist's contribution, it is well to confess that many engineers and chemists who prefer to rely largely on experiment are inclined to scoff at the usefulness of theory in chemistry. There is a feeling that the theoretical chemist is interested simply in mental gymnastics, has no regard for experimental results and that he is an ardent user of adjustable constants in his work.

This is an indictment that can be returned against some theoreticians, but there is enough first-class effort and results to make those of us inclined to use brute-



force methods pay attention to their output. To gain some perspective in this regard, it is only necessary to read a review of nineteenth-century vintage by the well-known organic chemist, Kolbe, on a book entitled "The Arrangement of Atoms in Space."

The book, authored by an upstart named van't Hoff, was denounced by the older chemist. Review is quoted in "Advanced Organic Chemistry" by G. W. Wheland (Wiley, New York, 3rd ed., p. 197).

At any rate, even if the quantum mechanical viewpoint is too esoteric for the pragmatic chemist and chemical engineer, the molecular approach via molecular dynamics and molecular architecture has been paying satisfactory dividends in indicating suitable points of attack on the frontier research problems. It probably follows that "molecular engineering" should stand a good chance of handling modern engineering problems.

## From Theory to Experiment

Turning to the laboratory now, it is likely that the development of greatest current impact is the use of spectra of all kinds. These spectra are important to the chemist because they provide some of the major experimental evidence of bonding, and because they are amenable to analytical application. In the long run, the former is more important, but to the chemical engineer the ability to detect readily reaction-mixture components in the plant, and in some cases to do quantitative analyses by these methods, is a major contribution also.

It is not appropriate here to more than mention the various techniques, for the literature is replete with both original and review articles on all of them. Ultraviolet, visible and infrared spectroscopic methods are familiar to all. Microwave spectroscopy is one of the more recent applications of the physicist's advances to elucidation of molecular structure. This adds one more weapon to the arsenal that, in principle, should eventually cover the whole electromagnetic spectrum.

X-ray methods have been of some use in analysis and in crystal structure work and now are proving to be quite important in detailing the structure of large, and often complex, organic molecules. In addition, the increasing availability and understanding of the neutron-diffraction technique makes it possible to place hydrogen more exactly in various structures.

The relatively new, but densely populated, research field of nuclear magnetic resonance and electron spin resonance has proved to be a major tool for the chemist in structural analysis and identification. Electron spin resonance has been particularly helpful in following free-radical possibilities. NMR has been of importance in organic structure work and in looking at hydrogen-bonded systems; and it is of some pertinence in surface studies.

Another tool that has had some effect is that of ultrasonic absorption. This has been useful in certain relaxation phenomena studies and appears to be applicable to liquid-state studies. Mass spectrometry, vapor-phase chromatography and other tools have all been very important in one way or another.

Immense progress has been made in crystalline solid state and kinetics studies. These areas are mapped

in other papers of this conference,* but note that two adjacent areas have not undergone anywhere near the same improvement. One is the liquid state, which has not been as intensively studied as most of the other areas mentioned here. The other is the very complex region of the interface between phases.

Surfaces have been the subject of intensive and extensive study, and reports on them occupy a large portion of the literature. However, the yield for the last decade had been notable mainly for proving that such a system is complex, and that there are many parameters.

This overstatement is made largely to underscore the point that heterogeneous catalysis is still not a highly scientific area in practice. This is a place where theoretical treatment is now becoming more prevalent and may well be the basis for greater progress than has so far been seen. Improvement in our position in solid-state physics and chemistry must surely also enhance the efforts in surface chemistry.

### New Means to Produce Chemicals

Another aspect of recent researches in chemistry that should be intriguing to the chemical engineer is the use of a variety of means of producing chemicals aside from the classical one involving thermal energy. For instance, biosynthesis, as a means for producing chemicals that are either not otherwise available or that can be made less expensively in this way, is being investigated.

The use of radiant or electrical energy to produce compounds is once again being looked at as an industrial possibility. In the latter case, the interest is an offshoot of activity in fuel-cell work. There is a hectic scramble to devise systems for the more-efficient, and preferably more-direct, conversion of fossil fuel or chemical energy to electric power.

The chemical engineer has a vital position in this effort to produce a practical fuel cell since there is cause for optimism about hydrogen-oxygen cells, and no real cause yet for pessimism about room-temperature hydrocarbon cells. High-temperature molten-salt cells also will require effective chemical engineering. The several other methods for increasing energy conversion effciency are no less important but may not be as pertinent to the interests of the chemical engineer, except for systems involving the use of nuclear energy.

Modern chemistry has not been loathe to concern itself with conditions that may be characterized as out-of-the-ordinary. There now are numerous efforts concerned with very-high or very-low temperatures, very-high pressures and nonaqueous systems. In part, this has been engendered by feedback from engineering problems stemming from the continuous effort to provide new chemicals, or to provide previously known chemicals more efficiently.

Such work has also stemmed from the serious interest of the chemist in the nature of substances that are under a much wider variety of conditions than those treated in textbooks. It also springs from his belief that with such experiments it will be possible to know molecular structure and molecular forces better. Whatever the reason for the interest, it does exist. Timely examples are two symposia on "extreme conditions" being given almost simultaneously with this conference at regional meetings of the American Chemical Society.

In a survey such as this, it would be lax not to call attention to a point of at least tangential interest. The chemist is no longer distinctly separated from the physicist or from the biologist (via the biochemist). In the latter case, the chemist is more and more concerned with complex natural materials and in the former with mathematical and purely physical concepts.

Underlying the work in each case is a vastly increased dependence on electronic instrumentation and on computational methods. This dichotomy may lead to the disappearance of the chemist as such, a point of some interest to the chemical engineer.

In closing, it must be emphasized that there has been no attempt to be exhaustive in this survey. Many areas of interest—for example, polymers and colloids in general—have been slighted. The best way to take care of this problem is to remind you that the annuals, such as "Annual Review of Physical Chemistry," provide a most effective means of following very recent research.

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Meet the Author

NORMAN HACKERMAN *is professor of chemistry and chairman of the chemistry department at the University of Texas, Austin. He is also dean of research and sponsored programs.*

*A native of Baltimore, he took his A.B. and Ph.D. at the Johns Hopkins University. Following several academic and industrial positions, including a year in the Manhattan District project with the Kellex Corp., he went to the University of Texas in 1945.*

*His research interests include electrochemistry, surface chemistry and corrosion of metals, and he has about 90 published research papers in these fields. He is technical editor of the Journal of the Electrochemical Society and a member of the board of editors of the ACS Monograph series. His societies include ACS, Electrochemical Society and National Assn. of Corrosion Engineers.*

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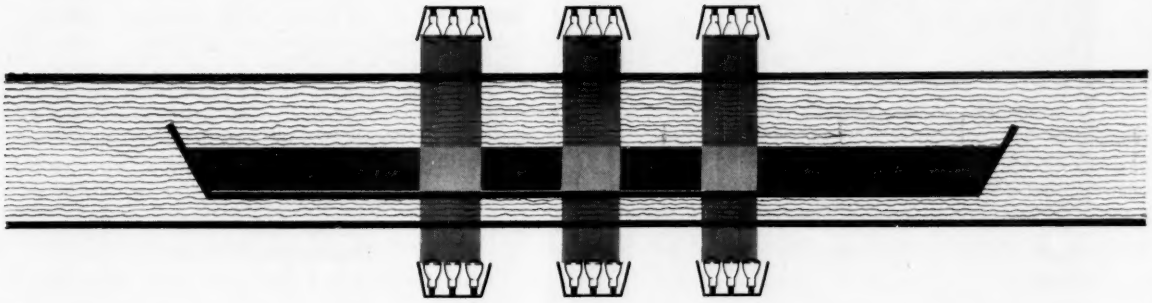
* See *Chem. Eng.*, Dec. 26, 1960, pp. 83-87, and this issue pp. 147-152.



# New Solid-State-Chemistry Methods Yield Ultrapure Materials

**Two simple, practical techniques for purifying solids: zone refining and single-crystal production. Very successful on semiconductors, methods look promising for making other pure metals and organics.**

ROWLAND E. JOHNSON, *Texas Instruments, Inc.*

New methods for purifying solids and producing single crystals have played a major role in the tremendous growth of the semiconductor industry in the last 10 years.

Commercial zone-refining and crystal-growing techniques produce ultrahigh-purity materials, so essential to semiconductors. A start has now been made in applying this knowledge to other systems such as metals and organic compounds. We can expect much wider application in the future with outstanding results.

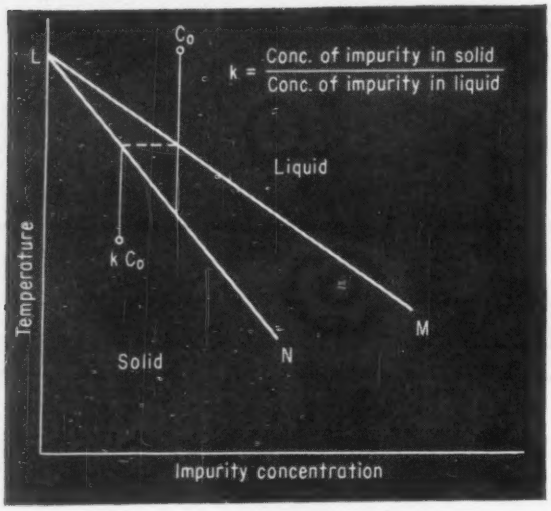
The purity problem is especially acute with semiconducting materials because their operation in transistors or rectifiers depends on a precise control of current flow. Among other things, current flow depends upon:

- Kinds of impurities present.
- Total amount of impurities.
- Excess amount of the dominant impurity.
- Polarity of the charge carriers (holes or electrons).
- Crystal perfection of the material.

A semiconductor's ability to carry current depends partly on impurities in the material. Different impurities produce different kinds of conduction.

The so-called n-type semiconductor contains an impurity whose atoms carry an extra electron. Thus,

## Impurity lowers melting point—Fig. 1




silicon could be doped with arsenic. This extra arsenic electron is available to carry current.

The p-type semiconductor contains an impurity with one less electron than the base material, as silicon with aluminum. Putting n- and p-type semiconductors together is the basis for many rectifier devices on the market today.

Two very popular base materials for semiconductors are germanium and silicon. Much research and development effort has centered on these materials, with important and significant results, particularly in purification techniques.

In practice, the problems of purity are best solved by making ultrapure materials and then introducing the proper impurity or impurities in required amounts. Crystal perfection is approached by growing single crystals with some attempt to control the number of dislocation and other lattice defects. It is imperative that no current leakage path such as a grain boundary be present in a transistor or rectifier, so the starting material for semiconductor devices is invariably a single crystal.

### Zone Refining Solves Purity Problems

Prior to the discovery of zone refining, semiconductor materials were either mined or synthesized, and used without further purification. Even today, a large amount of silicon is produced by high-purity methods and grown into single crystals without a purification step. However, as devices become more sophisticated and require purer material, an increasingly larger fraction of silicon must be zone refined. Germanium is easily and routinely purified by zone refining—one reason for the importance of germanium in semiconductors.

The basic idea of zone refining was disclosed by Pfann.[1] He observed that when a molten section or zone of a solid bar was swept longitudinally through the bar, the zone carried certain impurities with it and the process could be repeated with increased purification each time. Since the process depends upon a lowering of the melting point of a substance because of the impurities present, it is applicable to a wide range of substances and impurities. It can be made semiautomatic or automatic with relatively simple apparatus. It can be scaled up or down in size. While usually a batch operation, it can be continuous.

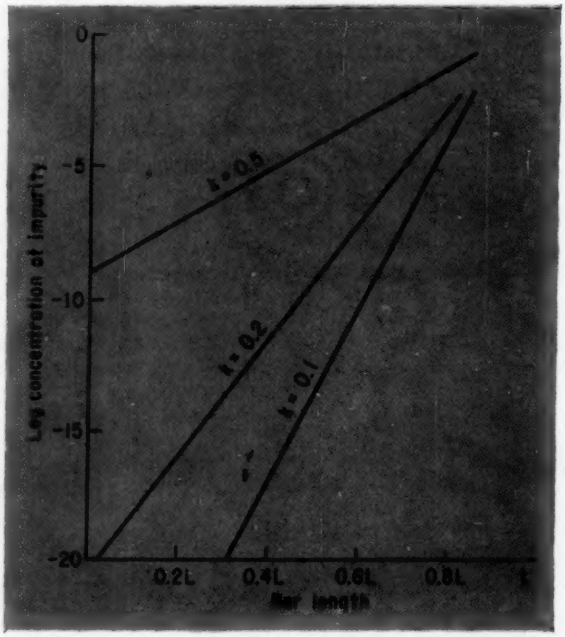
Fig. 1 shows part of the phase diagram for a substance whose melting point is decreased by an impurity. If liquid of composition $C_o$ is cooled, solid of composition $kC_o$ appears with lower impurity concentration. The segregation coefficient, $k$, is defined

$$k = \frac{\text{Concentration of impurity in solid}}{\text{Concentration of impurity in liquid}} \qquad 1)$$

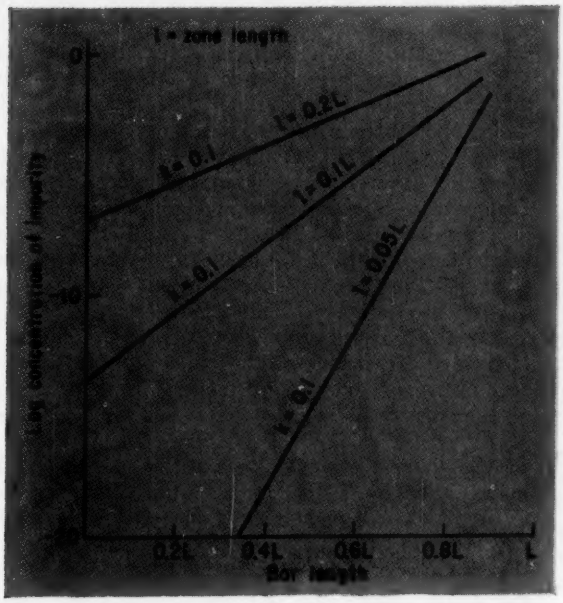
Line $LN$ can represent the solid solubility of the impurity or the solidus line for the system. Imagine a molten zone with impurity concentration $C_o$; then, the freezing process in Fig. 1 represents the process occurring at the freezing interface of the zone. Since the freezing solid is purer, the zone will be enriched by the impurity. However, the solid of the original composition, $C_o$, continually melts into the zone, and the composition of the solid follows line $LN$. At the end of the bar, the zone is frozen out and the impurity concentration there will be greater than $C_o$. There has been a net transport of impurities to the tail of the bar. If the process is repeated, impurities will again be carried to the tail.

## Impurity distribution limits—Fig. 2

**(for various segregation coefficients)**



## Impurity distribution limits—Fig. 3
**(for various relative zone lengths)**




### Practical Limitations on Refining

The final impurity profile in the bar will depend upon the segregation coefficient, number of passes and zone length, relative to the length of the bar.

Purification does not continue without end but, rather, a limiting distribution is approached as the number of passes increase. Fig. 2[2] shows the limiting distribution as a function of segregation coefficient. Fig. 3[2] shows the limiting distribution as a function of zone length. In general, the wider the zone, the more rapidly the limiting distribution is approached, and the narrower the zone, the lower the limiting distribution.

A segregation coefficient could be calculated from the equilibrium phase diagram of the system, if it were available, or from analysis of the infinitesimal first-to-freeze portion of a melt. However, the segregation coefficient describes an ideal quantity, impossible to achieve in practice. We must consider the following conditions that may perturb the system and make it nonideal:

- Equilibrium probably is not achieved at the freezing interface. The melt is not thoroughly mixed and impurities will build up at the interface. Speed of the moving zone will be a compromise between expediency and a desire for equilibrium conditions. Stirring of the melt may or may not be possible.
- Impurities may interact with one another depending upon the relative amounts of each.
- Temperature gradient at the freezing interface may allow supercooling and lead to uneven growth rates with trapping of impurities. Extremely steep temperature gradients would be desirable but they lead to physical defects in the crystal.
- A second phase may appear if its solubility limit is exceeded. (This rarely happens because the material usually has a relatively low level of impurities.)
- Polycrystallinity and crystal orientation change the behavior of impurities. Grain boundaries may act as sinks for impurities and there is evidence that impurities in indium antimonide segregate differently in different crystal directions.
- Rapid diffusion of impurities in the solid may destroy the impurity profile.

All of the above will change the action of impurities. Thus, an effective segregation coefficient is usually determined for each particular system. A bar is given a single pass and the impurity profile determined, for example, by radiotracers. The profile is compared with tabulated data,[3] and effective coefficient estimated within a factor of two. The number of passes necessary for a particular system is also commonly determined empirically, usually from experience with the starting material and the system.

Fortunately, impurities in germanium and silicon do not have unusual characteristics, with the exception of boron (table below). Germanium, made by a chemical process, will need about 20 passes. Silicon, from reduction of a silane or halo-silane, will need less than 10 passes.

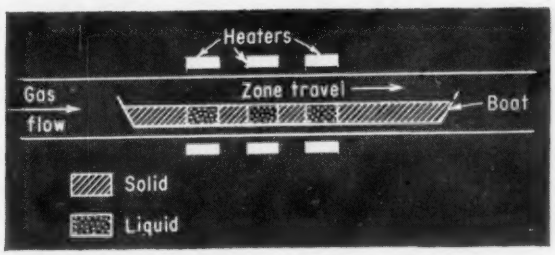
### Zone-Refining Equipment

Zone-refining apparatus is shown schematically in

## Segregation coefficients in silicon and germanium[7]

| Element | Segregation Coefficient $k$, in Si | in Ge |
|---|---|---|
| Copper | ..... | $1.5 \times 10^{-5}$ |
| Gold | $3 \times 10^{-5}$ | $3 \times 10^{-5}$ |
| Aluminum | $1.6 \times 10^{-3}$ | $10^{-1}$ |
| Gallium | $4 \times 10^{-3}$ | $10^{-1}$ |
| Indium | $3 \times 10^{-4}$ | $1.1 \times 10^{-3}$ |
| Arsenic | $7 \times 10^{-2}$ | $4 \times 10^{-2}$ |
| Boron | $6.8 \times 10^{-1}$ | 20 |

## How zone refining works—Fig. 4



**Refining gallium arsenide—Fig. 5**

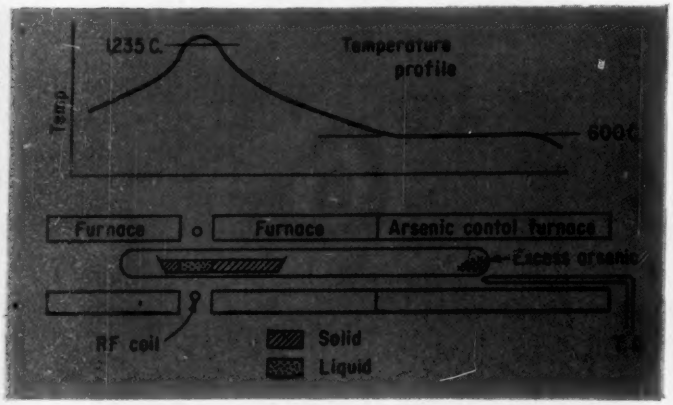



Fig. 4. A single zone can be carried with a single heater but multiple zones work much faster. In this figure, each pass of the heaters past the material carries three zones through the bar. The heaters may be anything capable of producing a molten zone such as resistance wires, radiofrequency coils or light beams. The boat must be nonreactive with the molten material. A gas stream usually runs through the tube to prevent oxidation and to carry off volatile impurities (hydrogen or helium with semiconductors).

Zone movement apparatus should be capable of speeds as slow as a few millimeters per hour and the entire zone-refining apparatus should be vibration-free. It is a simple design problem to automate the movement with a quick-return motor. For materials that expand on freezing (as does germanium), the apparatus must be tilted up a few degrees in the direction of zone travel to give an ingot of constant cross-section.

Compound semiconductors with a volatile component must be zone refined in a sealed system.[4] Fig. 5 shows an apparatus for gallium arsenide, a compound semiconductor, which melts at 1,235 C. with a dissociation pressure of 0.9 atm. of arsenic. A reservoir of excess arsenic is held at 600 C. where its vapor pressure exactly matches that of the molten gallium arsenide. Furnaces surround the rest of the system to prevent condensation of arsenic. Radiofrequency power is used to produce the zone; the furnaces and RF coil must be moved in unison past the gallium arsenide ingot. A similar system, inside a pressure vessel, has been used to zone refine gallium phosphide, which melts above 1,300 C., with a phosphorus pressure above 15 atm.

### How to Avoid Contamination

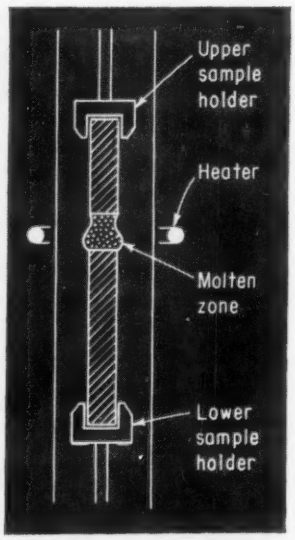
Many materials, such as silicon, will react with container materials and cannot be zone refined in the conventional manner. Keck and Golay[5] suggest floating zone refining to overcome this difficulty. A rod of material is clamped vertically and a molten zone produced by a suitable heater as in Fig. 6. Surface tension of the melt holds the zone in position and passes can be made along the length of the rod. Since the weight of material in the zone increases as does the square of the rod radius, while the surface tension increases as the radius, there is a limit to rod size that can be zone refined. Other considerations are the same as for horizontal zone refining.

In many cases, it is desirable to grow a single semiconductor crystal during the zone-refining process. Zone refining proceeds more uniformly in the absence of grain boundaries. Also, the single-crystal ingot can be doped to the proper impurity level during zone refining. The ingot can then be cut up and used directly in semiconductor device manufacture.

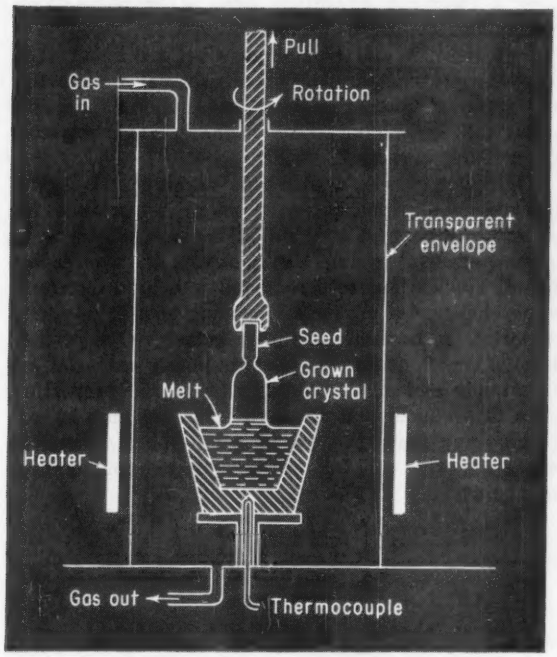
Growth of single crystals is extremely easy if a seed crystal is used to initiate growth. After sufficient zone refining, the tail end of the ingot containing most of the impurities is cut off and discarded. A seed crystal of the same cross-sectional size and shape as the zone-refined ingot is placed at the head end of the ingot. A molten zone is formed that links the seed to the ingot. When the molten zone moves, the material freezing out will be single crystalline and have the same crystallographic orientation as the seed. Successive passes of a molten zone will retain the single-crystal nature of the ingot.

If, in the final pass of a zone-refining program, a doping impurity with a small segregation coefficient ($k \leq 10^{-2}$) is introduced into the melt, that impurity will be distributed along the length of the ingot. Further, since $k$ is so small, only a very small amount of the impurity present in the zone will actually get into the ingot, and the amount in the zone will remain essentially constant. The result will be a bar that is single crystal and has a constant and controlled impurity concentration along its length. After slicing

**Floating zone refining—Fig. 6**



## Way to grow single crystals—Fig. 7




and cutting, the semiconductor material is ready for manufacturing into a diode or transistor.

For further details and discussions on many other aspects of zone refining, Pfann's excellent book[3] should be consulted.

### Crystal-Pulling Techniques

Of the many methods of producing single crystals of semiconductors, the Czochralski method has been the most widely used in the past and is still of major importance.

Fig. 7 shows a schematic representation of a crystal puller. The semiconductor is melted in a container, in an enclosed space. Very often, radiofrequency heating is used for melting. The container may be graphite for germanium, or a quartz liner on graphite for silicon. Hydrogen or helium are commonly used as protective gases to prevent melt oxidation. A single-crystal seed, previously prepared and held in a chuck, is dipped into the melt and a small amount of the seed melts off to give a fresh surface and to ensure wetting of the seed. Melt temperature is then lowered slightly and crystal growth starts on the seed. The seed is the coolest part touching the melt because the chuck acts as a heat leakage path.

Seed and growing crystal rotate continuously to stir the melt and to even out any inequalities in temperature distribution around the container. As the crystal grows down into the melt, the chuck and seed are slowly lifted. By regulating the power input and rate of lifting the crystal from the melt, strictly by visual observation and by experience, crystal growth rate is exactly balanced by the lifting rate, and a uniform-diameter single crystal grows.

Very little auxiliary equipment is necessary. A very sensitive, fast-acting temperature controller with manual setting controls the melt temperature. Varying the melt temperature controls the crystal shape.

Introducing small amounts of impurities to the melt during crystal growth may be desirable. The entire crystal pulling apparatus should be vibration-free. Spinning rates are usually variable up to 100 rpm., and pull rates may be anywhere from zero up to 10 in./hr.

As the crystal grows, distribution of impurities occurs between the liquid and solid so that

$$C_s = kC_o\,(1 - x)^{k-1} \qquad (2)$$

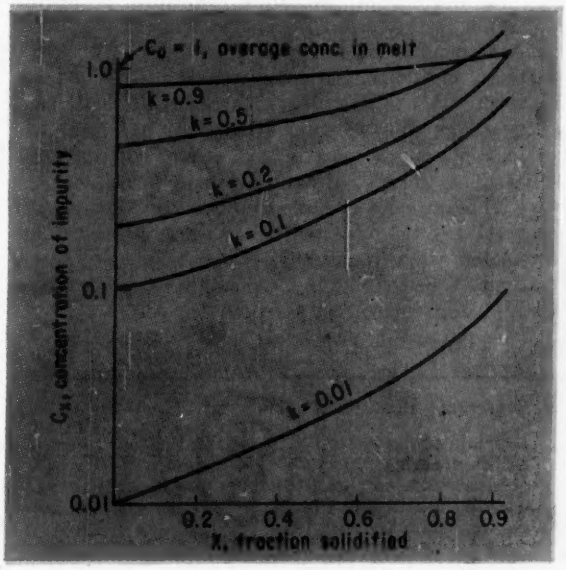
where $C_s$ is the concentration of impurity in the solid after a fraction $x$ of the melt has solidified; $k$ is the segregation coefficient, defined previously; $C_o$ is the original concentration of impurity in the melt.

Eq. (2) applies to normal freezing, and also represents the case where a molten bar of material slowly solidifies from one end. Fig. 8 shows the curves of $C_s$ vs $x$.[1] Distribution of impurities will occur during crystal pulling but usually the material growing into a crystal is so pure that the effect of impurities will be small—or an impurity can be deliberately introduced to give a desired effect.

### Crystal-Pulling Refinements

Most of the perturbations on the zone-refining segregation coefficient apply to crystal pulling as well. However, spinning the crystal stirs the melt thoroughly,

## Impurity builds up in solid—Fig. 8



smooths out the temperature gradient, and prevents supercooling. In general, a crystal pulled from a melt will be more homogeneous than a crystal grown in a zone refiner.

Considerable time and effort has been spent on developing crystal pullers for use with compound semiconductors that have a volatile component, such as gallium arsenide. In one system, a magnetic drive rotates and lifts the chuck and seed inside a sealed quartz enclosure. Suitable furnaces are used to control vapor pressure of the volatile component, and radiofrequency heating is used to melt the material.

In other systems, motion is imparted by close-fitting quartz or graphite pistons rotating inside precision quartz cylinders. The small leak past the rotating surfaces can be tolerated for the time necessary to grow a crystal. Because of equipment difficulties, it is not considered practical to pull crystals if the system has to operate at more than about 2 atm.

For more complete details on the preparation and growth of single crystals, see Ref. 6.

## Future Considerations

At present, semiconductors are the only materials manufactured using crystal pulling and zone refining as production techniques. Costs involved in the two techniques are not negligible. High-purity germanium is available in single-crystal form at about $180/lb. Polycrystalline silicon of reasonable purity will be about $100/lb. High-purity single-crystal silicon of a specified impurity level will cost about $1,000/lb. Germanium, as mentioned previously, is a reasonably easy material to zone refine and to grow into single crystals in one operation. Silicon is much more difficult, of course, and the increased purity and single-crystal nature represent increased value of the silicon.

In spite of the heavy costs of production, there is a steady demand for high-purity, single-crystal germanium and silicon. Including companies producing and using the materials internally, some tens of thousands of pounds are produced annually.

Today, in addition to semiconductor work, a large research effort is going on with reactive metals such as titanium, molybdenum, zirconium, hafnium, and so on. Usually, the goal is high purity without bothering about the crystal nature although crystal structure will become more important in the future. The properties of the pure metals are being evaluated and correlated when possible with the impurity concentrations. Zone refining in a vacuum is especially useful for reducing volatile impurities.

Zone refining is also being used to purify organic materials, particularly as a supplement to other well-known methods of purification. The technique does not have a clean-cut advantage over other purification methods but is useful in special cases.

Zone refining and crystal growing are being used to a lesser extent on many other materials: removing salt from sea water; growing or purifying inorganic salts; and producing some organic single crystals (scintillator crystals).

The batch processes for zone refining and crystal growing will probably be of major importance for many years because of the experimental difficulties in any continuous system. In general, we can expect future applications to closely follow behind discovery or development of products depending upon high-purity material. In the semiconductor industry, the production of small quantities of high-purity material led to a study and understanding of material properties, then to products that required large amounts of material. Any industrial use of a high-purity metal or other material will follow the same general development line.



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Meet the Author

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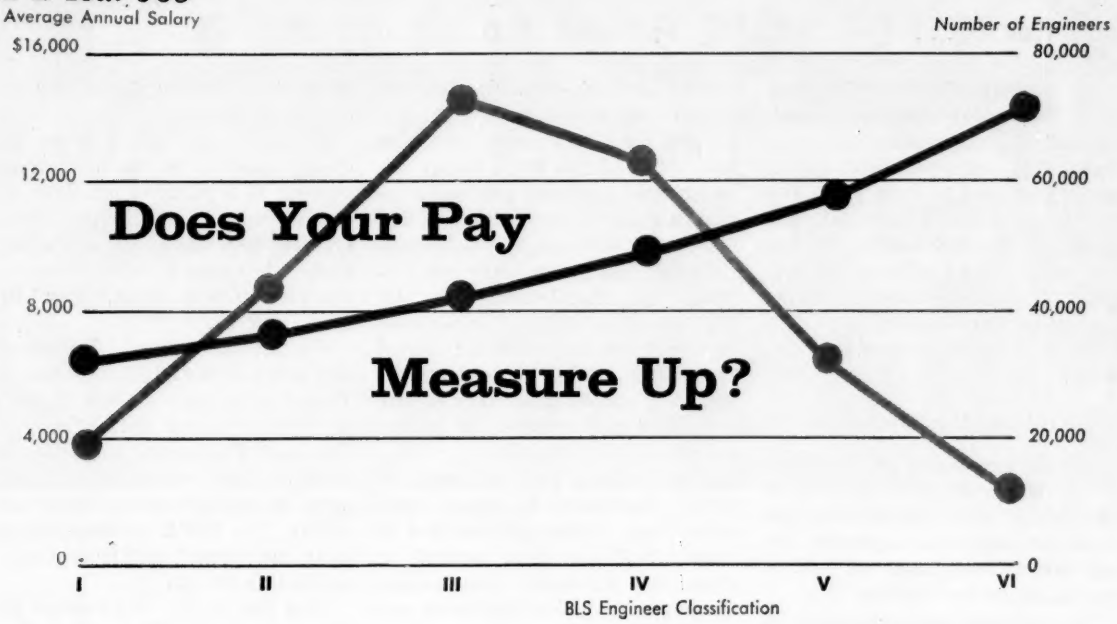


# Does Your Pay Measure Up?

***A first-time study by Bureau of Labor Statistics shows that engineers in industry are better paid than chemists, not as well-paid as attorneys.***

The government's new yardstick for measuring pay (*Chem. Eng.*, Jan. 11, 1960, pp. 120-122) has just lined up data on 247,000 engineers. You may be among them.

And this Bureau of Labor Statistics study,* collected through personal interview with company officials in over 1,600 firms employing 100 or more workers, shows:

- Engineers in industry earn on the average from $6,371 to $14,193 annually, depending on which of six classifications describes their duties.
- In each classification, a quarter or less of these engineers receive cash bonuses.
- An overwhelming majority of firms employing engineers make no pay distinction on basis of field of specialization or function.

Data on engineers pay are included in a broader survey of white-collar pay in industry. The six definitions prepared for collection of data on engineering salaries reflect this, but these definitions were designed to be translatable to specific pay grades in the general schedule applying to Federal employees.

When we first reported on this new study just a year ago, we described briefly what the six classifications for engineers are. You can turn to our report, too, for other background information on the BLS work. Most data were collected from January to June 1960.

## What Study Says About Salary

Average monthly salaries for the six engineering classifications shaped up like this: (*i*) $529, (*ii*) $602, (*iii*) $699, (*iv*) $820, (*v*) $966, (*vi*) $1,180. Chemists ranged from $460 to $1,138 monthly in six similar categories, mathematicians from $481 to $1,251 in seven job definitions.

Attorneys, starting lower than engineers at $497/mo., end higher at $1,913/mo., with over two thirds of them paid as high or higher than the senior engineering classification. And 1,148 directors of R & D receive an average of $1,512/mo.

Although the survey wasn't designed to show quantitative differences between geographic regions or major industry divisions, the Bureau does have some qualitative comments. The spread between highest and lowest of four U. S. regional averages was less than 5% for engineers and scientists.

Several industries—manufacturing, transportation, communication, electric, gas and sanitary services—showed similar salary levels for engineers as well as other occupations. Average salaries for these industries were above all industries combined.

In engineering and architectural services, and R & D and testing labs combined, salaries were slightly above those for manufacturing and public utilities industries.

However good salaries are, engineers tend not to do too well by cash bonuses. Of those who receive bonuses, the top engineering group adds, on the average, only 3.2% to its pay; others, much less.

* BLS Bulletin 1286, "National Survey of Professional, Administrative, Technical and Clerical Pay, Winter 1959-60." Order from Supt. of Documents, Washington 25, D. C. (35¢).

It's probably just as well that most (over three-quarters) engineers don't get bonuses—the study shows that employees who do receive them tend to have lower salary rates (excluding bonuses) than those on straight salary. Of the companies (41%) offering bonuses, about three-quarters distributed the largess at Christmas or year-end; most of the rest, as profit-sharing plans.

### Some Interesting Byproducts

Several byproducts of the salary survey emerged: characteristics of the salary rate system, entrance rates for beginning engineers and pay distinctions based on field of specialization or function.

Not included was information on such supplementary benefits as paid vacations and holidays, and health, insurance and pension plans.

Almost two-thirds (63%) of the firms employing engineers and scientists had no formal salary rate policies. Salaries were determined on an individual basis. Breaking down the 37% with formal policies, 36% had a range of rates, with maximum and minimum rates specified, and the remaining 1% had a single rate.

Of those firms with formal plans, nearly two thirds did not specify intermediate dollar rates, but had definite policy to determine progression within the range. Progression policy, in 85% of the firms, provided periodic merit review; 1% had automatic increases after a specified period; 14% combined automatic and merit increases.

And it doesn't seem to make much difference what your job function (say, process design) or specialization (say, chemical engineering) is. In those firms employing engineers in two or more fields of specialization or function, over 90% make no pay distinction on this basis. The rest make distinctions at all or most job levels.

### For Beginners in the Profession

Of particular interest to college seniors seeking industrial jobs are the hiring policies of potential employers—about half have formal policies, half do not. One out of three of those that do have formal policies hires at a single rate; the rest—32% of the firms hiring inexperienced college graduates — offer a salary range to prospective employees.

In this last group, there are several criteria that determine the hiring salary. In order of importance to most firms, these include: related experience (prior to graduation), scholastic standing, military service completed and evidence of leadership.

Single salary rate or range of rates, beginners do pretty well either way. Under policies that in nearly half the firms applied to June 1960 graduates, the median for engineers under single-rate policy was $476/mo., under rate-range policy, $478/mo.

A few newcomers under both policies started at less than $360/mo., a few started at over $540. (According to most estimates, beginning chemical engineers are well above this median figure for all engineers.)

It will be interesting to see industry reaction to the new study, because BLS plans to put it on an annual basis. Engineers Joint Council, which runs its own salary survey, has already raised some objections (*Chem. Eng.*, Mar. 21, 1960, p. 218).

On the other hand, the nature and scope of the BLS study may fit in well with some already existing surveys. National Society of Professional Engineers, for example, defines eight engineering levels, could go to six to make comparison easier. The NSPE biannual survey of its membership will be conducted again this spring.

And the survey of Canadian engineers' salaries (*Chem. Eng.*, Dec. 12, 1960, pp. 168-169) uses six levels to define professional responsibility.

Now, however, you have one more yardstick against which you can measure your material progress.

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# NSF Finds Where You Are

***The Federal government has compiled more facts on engineering and scientific personnel in industry. This National Science Foundation survey tells about it.***

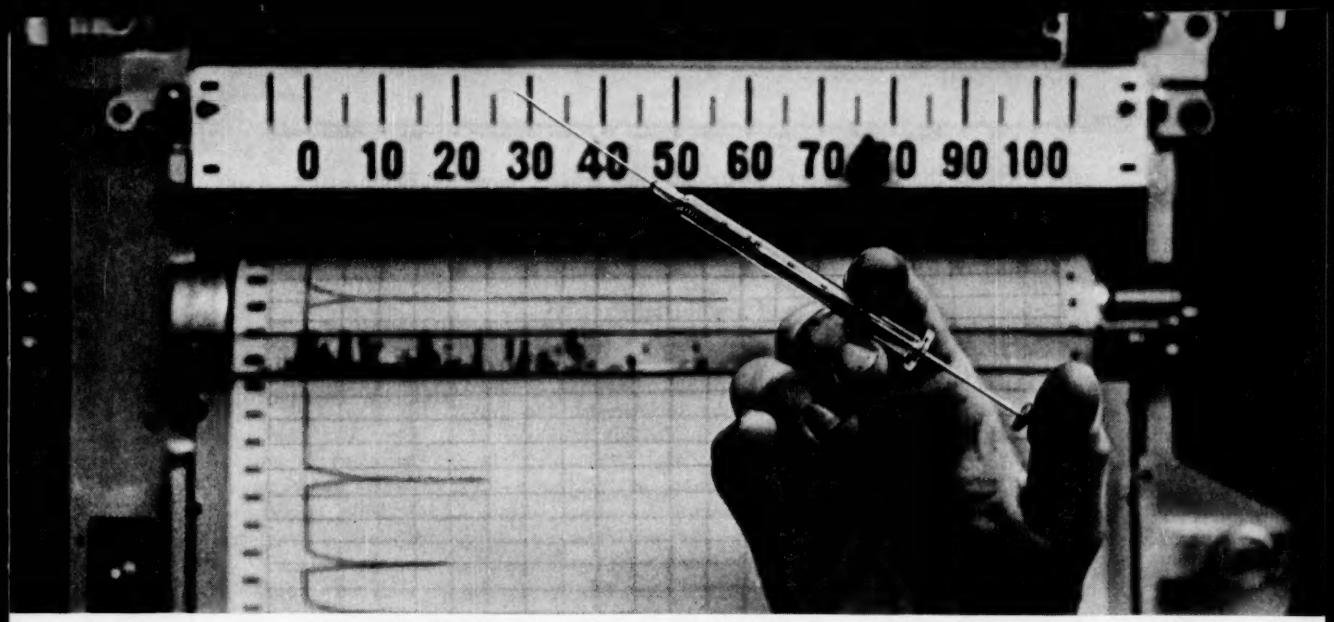
Another survey conducted by the Bureau of Labor Statistics, just released, reports on distribution of technical personnel in industry as of January 1959. Preliminary data for January 1960 have also been issued.

Prepared for the National Science Foundation, "Scientific and Technical Personnel in American Industry"* follows up two earlier reports (January 1954 and January 1957) that were concerned primarily with R and D activities. The new report carries figures on engineers and scientists primarily engaged in R & D, management, production and other functions.

Although various manufacturing and nonmanufacturing industries are shown individually, we'll concentrate here on "chemicals and allied products." And in this category, 44% of all companies employed engineers and scientists—all the firms included in the survey with over 5,000 employees, most firms with over 500 employees, but only 40% of those with under 100 employees.

Scientists and engineers, then, made up 9% of total employment in chemical and allied products—10.6% of the total in firms of over

* (NSF 60-62). Order from Supt. of Documents, Washington 25, D. C. (45¢).




*Gas chromatography does complex solvent analyses in minutes. Here, a Shell chemist prepares a sample for injection.*

# BULLETIN:

## Shell Chemical announces a monograph describing 31 tests—some standard, some ingeniously devised—to give you greater insight into surface coatings.

**Shell uses these 31 tests as a backbone in lacquer formulation. They have led to startling concepts such as *the advantages of solvent retention* and to remarkable new high boiling solvents such as Pent-Oxone* *keto-ether* and Pent-Oxol* glycol ether.**

**Read how you can get an indexed, 60-page copy of this monograph telling how to set up these 31 tests, how to run them and *how they can help improve your current formulations.***

THE 31 tests used regularly at Shell Chemical's Technical Service Laboratory in Union, N. J. have led to some fascinating new fields of investigation. One is solvent retention.

### A twist on solvent retention

While slow solvent release is known to cause film shrinkage and have a bad effect on print resistance, *retained* solvent has recently been found to have *good* effects on gloss retention and restoration, cold crack resistance and weatherability.

Test 29 can help you study these dual effects in terms of *what actually happens when lacquer dries.*

### Two remarkable new high boilers

Studies of this type led directly to Shell Chemical's two remarkable new high boilers: Pent-Oxone *keto-ether,* particularly promising in formulations with *dissimilar resins* and Pent-Oxol glycol ether for *maximum blush resistance/practical drying time* in nitrocellulose lacquer formulations.

### How to get your monograph

To get your monograph, write or call any of Shell Chemical's 12 district offices throughout the U. S. and Canada. Or write Shell Chemical Co., 110 West 51 St., New York 20, N. Y.

**Samples and information**

When writing for a copy of the monograph, ask for samples and information on any of these items:

| | |
|---|---|
| Acetone | Isopropyl Ether |
| Bisphenol-A | Mesityl Oxide |
| Diacetone Alcohol | Methyl Amyl Acetate |
| Di-tertiary-butyl peroxide | Methyl Ethyl Ketone |
| | Methyl Isobutyl Carbinol |
| Ethyl Alcohol | Methyl Isobutyl Ketone |
| Ethyl Amyl Ketone | Neosol® Solvent |
| Glycerine | Pent-Oxone* Keto-ether |
| Hexylene Glycol | Pent-Oxol* Glycol Ether |
| Isopropyl Alcohol | Secondary Butyl Alcohol |

*Trademark, Shell Chemical Company

A Bulletin from

**Shell Chemical Company**

SHELL

**Industrial Chemicals Division**

5,000 employees, 5.9% of the total in firms smaller than 100 employees —and 60% of these scientists and engineers were employed in the largest (over 5,000 employees) firms.

Of these engineers and scientists —83,100 in all—36,600 were engineers, 31,100 were chemists. That's 6% of the engineers in all industries and 44% of the chemists, and it represents a 3.9% growth over the January 1958 figure of 80,100.

Total employment of engineers and scientists in the firms covered grew 4.6% in the same period—from 730,500 in January 1958 to 764,100 in January 1959. And preliminary figures for January 1960 show a 6.7% increase, from 764,100 to 815,500, a percentage increase also reflected in the engineers category.

Engineers, over half of them being in the largest firms, made up 615,400 of the 764,100 engineers and scientists in all companies. (Preliminary figures for January 1960 show 656,300 engineers.)

### Distribution by Function

Engineers in research and development number 174,800, a whopping 28% of all engineers. Too, another 5%—30,800 in number—manage and administer R & D programs. But the chemical industry allocates slightly less effort in this direction—27% of its engineers in R & D, 4% in R & D management.

When scientists are added to engineers, chemicals devote 36% of their technical manpower to R & D and nearly 5% to management of these activities. Between chemists and engineers, this totals nearly 28,200 people.

Of the 36,600 engineers in chemicals—beside the 31% in R & D—7% (2,300) manage activities other than R & D, 45% (16,400) are in production and operations and the rest are in all other activities.

Chances are about 3 to 1, between R & D and production, that if you're in a small company, you're in the latter function. But in the largest firms, it's about 50-50 for the two, with just a slight weighting toward R & D.

Although only 3 out of 4 engineers in industry as a whole have college degrees, in the chemicals sector over 9 out of 10 engineers have a bachelor's or higher degree.

### Use of Technicians

Since support for all this scientific and technological effort must be given by technicians, the survey's findings in this area are of interest.

Six percent of all-industries' 550,000 technicians work in chemicals and allied products. Supporting the industry's 83,100 scientists and engineers, these 34,400 provide an average of 41 technicians per 100 professionals. For industry as a whole, there are 72 technicians per 100 professionals. NSF attributes the low ratio in chemicals to the relatively few draftsmen employed in this industry sector.

Among R & D personnel, however, 47 technicians support each 100 scientists and engineers in chemical and allied products.

National Science Foundation is trying to cut the lead time between collection of data and publication of the results of this survey. It promises final returns on data of January 1960 "early in 1961." When they're available, we'll bring them to your attention.

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## Booklet Offers Handy Tips For Considering Grad Work

A new booklet gives practical advice on problems and rewards of graduate study. "The Road to Graduate School" was prepared by the University of Illinois chapter of Tau Beta Pi and published by ASEE, under a Ford Foundation grant.

The 20-page booklet probes whether one should actually go on to advanced studies, how to pick a school, how to finance the several extra years of academic life. A convenient calendar summarizes what the undergraduate should do about inquiries and applications. It emphasizes the need to start thinking early—in the spring of the junior undergraduate year.

Engineering deans and local chapters of Tau Beta Pi are distributing the booklet.

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## University Helps Engineers Renew the Fundamentals

The University of California (Berkeley) is now offering a nationwide refresher course to help practicing engineers bone up for professional registration or advanced study.

The new course—"Engineering Fundamentals"—covers the first, or closed-book portion of the engineering registration exam in any of the 50 states or three territories.

Meanwhile, UCLA has announced a six-week summer course on modern engineering for engineering executives.

Designed to train industrial leaders in technology needed for decision-making, the course will try to update university-days training of these executives. Participants for this year's session have already been chosen, and have paid their $2,340 fee.

Information on the first course is available from University Extension, Berkeley 4, and on the second from University Extension, Los Angeles 24. Both are branches of the University of California.

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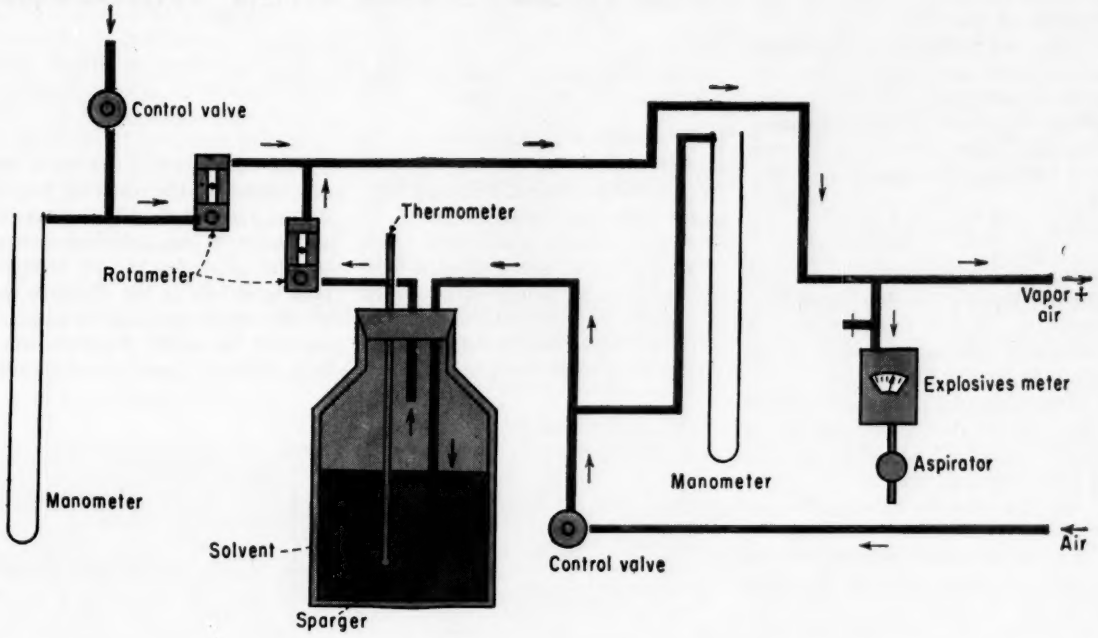
## 15th Annual Job Survey

According to Northwestern University's latest Endicott survey, companies plan to hire 6% more engineers in 1961 than they did last year, at an increase over 1960 starting salaries.

In the survey covering 210 firms, reporting companies said they planned to pay an average of $520/mo. to starting engineers. Of graduates hired five and ten years ago, the survey shows that engineers still hold salary advantage over graduates of other disciplines. The engineering graduate hired in 1955 averaged $371/mo. and is now making $682/mo.




# Solvents Calibrate Explosives Meter

**Winner of the November Contest**

W. A. DICKENS, *Kimberly-Clark Corp., Neenah, Wis.*

An explosives meter is a common item of equipment in plants where potentially combustible or explosive solvents are handled. In such a plant, it is wise to calibrate the meter for the particular solvents involved. This simple calibration apparatus will give a rapid and accurate calibration, or will check the meter for catalyst fouling.

The solvent-containing stream is generated by bubbling compressed air through a sparge plate immersed to a depth of about 6 in. in the solvent. This provides a stream of air essentially saturated with the solvent. The air-solvent stream is mixed with an air stream to provide the desired dilution; and the mixed stream, after flowing through about 5 ft. of glass tubing, is sampled by the explosives meter. Small rotameters measure both streams.

By measuring the solvent temperature and referring to its vapor-pressure curve, the volume % of solvent in the solvent-saturated stream can be measured. This percentage can be varied, if desired, by varying the solvent temperature. The volume % of solvent in the vapor-air stream can be calculated from the following equation:

$$\text{Volume } \% = \frac{\%S_1 \times F_1}{F_1 + F_2}$$

where $\%S_1$ is the volume % of solvent in the solvent-containing stream, $F_1$ is the flow rate of the solvent-containing stream, and $F_2$ of the air-diluent stream.

# REFLUX DRUM DESIGN - CASE 2

S. H. FRIEDMAN,
J. W. MURTHA
*Bechtel Associates, New York*

This is the second in a series of process-design notes that present empirical methods developed from the author's experience. This article considers the second case for the design of a distillation reflux drum —both liquid and vapor present in the column overhead. The first article (*Chem. Eng.*, Nov. 14, p. 235) treated the liquid-only case.

All design criteria remain the same as in the first case except that the vapor space is determined by the critical area $A_{cs}$, which is the space between the high liquid level HLL and the top of the vessel. This

is the space available for the noncondensing gas flow.

After finding length and diameter of the drum as outlined in the first article, determine the critical velocity $V_e$, which is the maximum allowable vapor velocity in ft./sec. Use this empirical equation:

$$V_e = 4.05\sqrt{\frac{ST}{MP}}$$

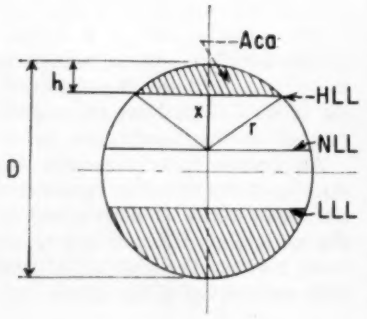
where $S$ is the specific gravity of the hot liquid; $T$ is the vapor temperature, °R.; $M$ is the molecular weight of the vapor and $P$ is the absolute pressure, psia.

The value of $V_e$ calculated in this way should be multiplied by a safety factor of 1.7 to be sure of vapor disengagement.

Next, divide the volume of vapor passing overhead in cu.ft./sec. by $1.7V_e$ to give the required critical area, $A_{ca}$. Now, based on the drum diameter assumed previously, calculate the total cross-sectional area.

Using the ratio $A_{ca}/A$ ($A$ is the total area), go to the table, "Areas of Segments," in "Chemical Engineers' Handbook," J. H. Perry, 3rd ed., page 32, McGraw-Hill, 1950, and find the equivalent $h/D$ ratio. Since $D$ is known, calculate $h$. This is the distance required between HLL and the top of the drum to provide sufficient vapor space. Compare this value to that assumed previously (as outlined in the first article). The assumed value must be at least as great as the calculated value of $h$ and preferably a little larger. If it is not large enough, the drum size must be revised.

The next article in this series will consider the third and last case for distillation reflux drums—liquid product, vapor and water all present in the overhead.



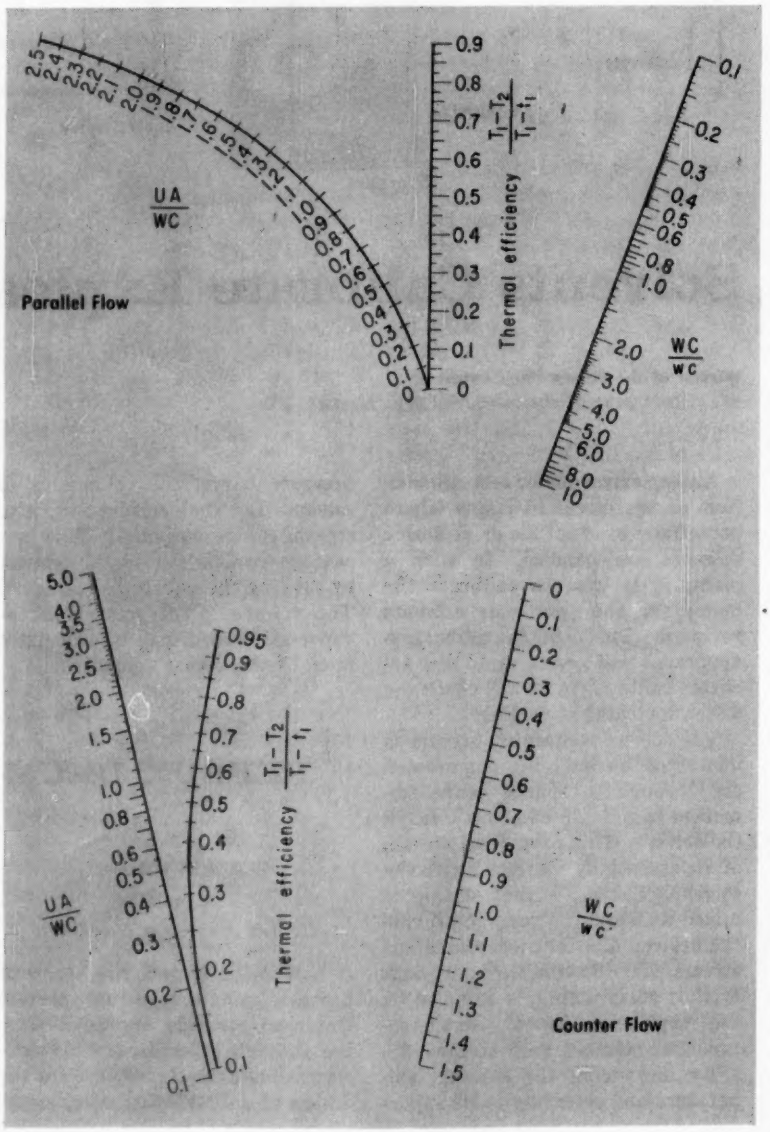

# USE CURVES FOR HEAT TRANSFER

VED SWARUP GUPTA, *Bhilai Steel Works, India*

An article by Irving Granet (*Chem. Eng.*, March 1955, p. 187) presented performance curves to find heat-transfer coefficients.

These curves are presented here in the form of nomographs, which are easier to read and use than the original versions. The following example illustrates their use.

Cold water at 60 F. enters a heat exchanger at the rate of 100 cu. ft./hr. The hot fluid flows at a rate of 20,000 lb./hr. and has a mean specific heat of 0.18. Its temperature is 500 F. If the effective area of the exchanger is 450 sq. ft., determine the outlet temperature of both fluids for parallel and counter-



flow operation. Assume the heat-transfer coefficient to be 10.

Assume $W$ is the flow rate of hot fluid, lb./hr.; $w$ is the flow rate of cold fluid, lb./hr.; $A$ is the surface area, sq. ft.; $C$ is the specific heat of the hot fluid (constant pressure), Btu./(lb.)(°F.); $c$ is the specific heat of the cold fluid; $U$ is the overall heat-transfer coefficient based on outside surface, Btu./(hr.)(sq.ft.)(°F.); $T_1$ is the temperature of the hot fluid, °F.; $t_1$ is the inlet temperature of the cold fluid, °F.; $T_2$ is the outlet temperature of the hot fluid, °F.; $t_2$ is the outlet temperature of the cold fluid, °F.

$$\frac{UA}{WC} = \frac{10 \times 450}{20{,}000 \times 0.18} = 1.25$$

$$\frac{WC}{wc} = \frac{20{,}000 \times 0.18}{6{,}240 \times 1.0} = 0.577$$

For parallel flow, from the nomograph, the thermal efficiency is approximately 0.54.

$$\frac{500 - T_2}{500 - 60} = 0.54$$

$$T_2 = 262 \text{ F.}$$

The heat given out is:

$$(500 - 262)\ 0.18\ (20{,}000) = 856{,}000 \text{ Btu.}$$

This is approximately the heat taken in by the cold fluid. Therefore, the temperature rise is:

$$\frac{856{,}000}{6{,}240 \times 1} = 137 \text{ F. and } t_2 \text{ is } 197 \text{ F.}$$

Similarly, results can be obtained for counterflow operation.

## Test Your CEQ

BY ROBERT LEMLICH

At a certain remote, unmanned installation, the gage pressure in a special isothermal cylinder of gaseous argon (supposedly closed) was automatically recorded as 14 in. of water at 1:00 P.M., 9 in. at 1:30 P.M. and 4 in. at 2:00 P.M. If this decrease was caused by leakage through a hairline crack of fixed dimensions that resulted instantly from a nearby explosion, at what time did this probably occur?

*(Answer on page 160)*

**Winner of the $100 Annual Prize for 1960***

***Each year, the editors of Chemical Engineering judge the monthly Notebook winners for the previous twelve months. The best of these is awarded an additional $100 prize. Here, then, is the yearly winner for 1960.***

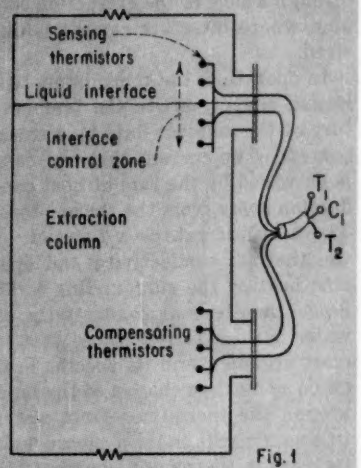



Fig. 1

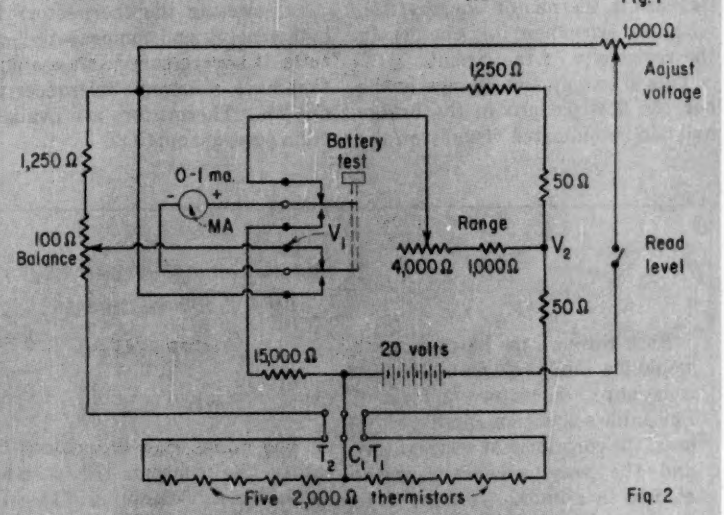



Fig. 2

# THERMISTOR INTERFACE CONTROL

FREDERICK FAHNOE, *Technical Supervisor*

*Mallory-Sharon Metals Co., Ashtabula, Ohio*

Pictured above is a solution to a common problem in liquid extraction systems—measurement and control of the interface between the organic and aqueous phases. A bridge circuit containing balanced thermistor sensing units provides the solution.

A thermistor is a ceramic material that has a negative coefficient of resistance, i.e., decreasing electrical resistance with increasing temperature. In some materials, the resistance can be doubled with a temperature change as small as 15 C.

Fig. 2 shows a wheatstone bridge circuit that is suitable for interface control with thermistors. It has a constant voltage source and a set of temperature-compensating thermistors in one arm of the bridge. These are shown submerged in the heavy phase in Fig. 1 while the

*This article, originally published in the Feb. 22 issue, was selected by the editors as the best monthly Notebook winner for 1960. The author will therefore receive an additional prize of $100.

sensing thermistors are staged through a zone in the extraction column where interface control is desired.

In operation, the thermistors are heated slightly above the temperature of the ambient fluid by a small current. The current that can pass is governed by the rate of heat conduction away from the thermistors. The heat-loss rate is a function of the thermal conductivity and specific heat of the surrounding fluid. Since the thermal conductivity of water is three to four times that of most organics, and its specific heat twice as much, a change of the fluid around the thermistor from water to organic will cause a measurable increase in thermistor temperature, with an accompanying change in the resistivity of the circuit.

This shows up as a change in the current flow pattern in the bridge and can be indicated visually on the milliammeter. For automatic control, the voltage developed across the bridge terminals $V_1$ and $V_2$ can be fed to a transducer to activate the required control valve operators.

The circuit shown is easily constructed, using five ganged 2,000-ohm thermistors for each of the sensing and compensating elements. The circuit can be adjusted to give full-scale indication over the interface control zone. The thermistors we used are Glennite thermistor beads, which are enclosed in glass probes. These units have a temperature coefficient of resistance of –3.9%/°C. and a heat dissipation in free air of 1 milliwatt/°C.

In selecting the thermistors for both sensing and compensating circuits, it is necessary to choose units that have resistance tolerances under 2%. Thermistors are available from several suppliers.



*Answer to "Test Your CEQ"*

Flow through the hairline crack would be laminar (possibly with some slip). Therefore, a form of Poiseuille's equation applies. However, the constancy of temperature and the very small percentage change in absolute pressure indicate a negligible change in kinematic viscosity. Thus, for a crack of constant dimensions, Poiseuille's equation reduces to the simple proportionality.

$$\text{Flow rate} \propto P_g \qquad (1)$$

where $P_g$ is gage pressure

Now, for the cylinder's variable contents,

$$PV = WRT/M \qquad (2)$$

or

$$W = PVM/RT \qquad (3)$$

or

$$\frac{dW}{d\tau} = \frac{VM}{RT}\left(\frac{dP}{d\tau}\right) \qquad (4)$$

where $\tau$ is time.

But,

$$P = P_g + P_b \qquad (5)$$

so that for fixed barometric pressure $P_b$,

$$dP = dP_g \qquad (6)$$

Also,

$$\text{flow rate} = -\frac{dW}{d\tau} \qquad (7)$$

The minus sign is included because the contents $W$ decrease with time. Combining (1) with (4), (6) and (7), and noting that $VM/RT$ is constant, yields, after simplification,

$$-\frac{dP_g}{d\tau} = KP_g \qquad (8)$$

where $K$ is a proportionality constant.

Eq. (8) is similar to that for an irreversible first-order chemical reaction and can be solved in the same manner. Separating variables,

$$-\frac{dP_g}{P_g} = Kd\tau \qquad (9)$$

Integrating without limits gives the following:

$$\ln P_g = -K\tau + \text{constant} \qquad (10)$$

Plotting this on semilog paper, with $P_g$ on the logarithmic axis and $\tau$ on the arithmetic, should yield a straight line for any time interval after the leak started. Accordingly, such a straight line drawn through the last two points and extended back to a $P_g$ of 14 shows that the explosion occurred at about 1:07½ P.M.

Alternatively, Eq. (10) can be solved analytically rather than graphically by, for example, equating slopes

$$\frac{\ln 14 - \ln 9}{\tau_e - 30} = \frac{\ln 9 - \ln 5}{30 - 60} \qquad (11)$$

Solving for $\tau_e$ yields the same result as plotting.

Note that drawing a straight line through either of the other two possible pairs of points would result in an absurdity. This is perhaps more evident from a graphical solution but, of course, follows from the analytical solution as well.

*CE Cost File*

# No. 48: COST-CAPACITY DATA II

***Here are three more cost-capacity curves for ethylene-based chemicals. Clip and file with Cost File No. 46.***

JONAS M. BERK, JOHN E. HASELBARTH

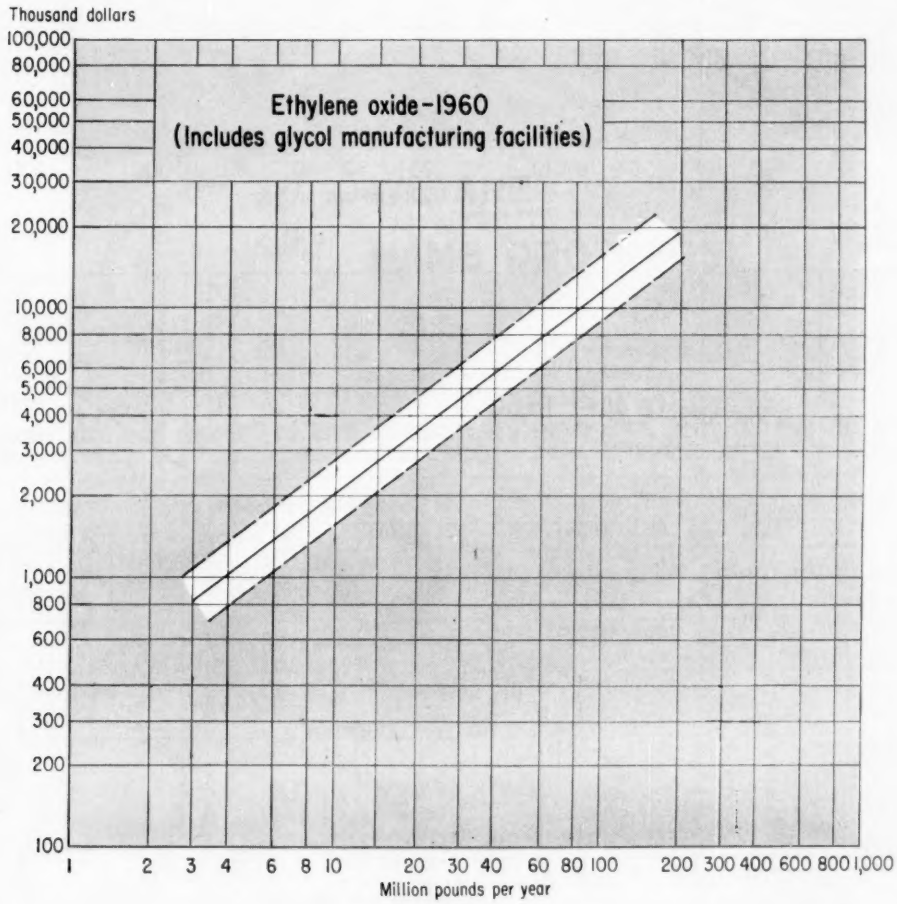
*Houston, Tex.*

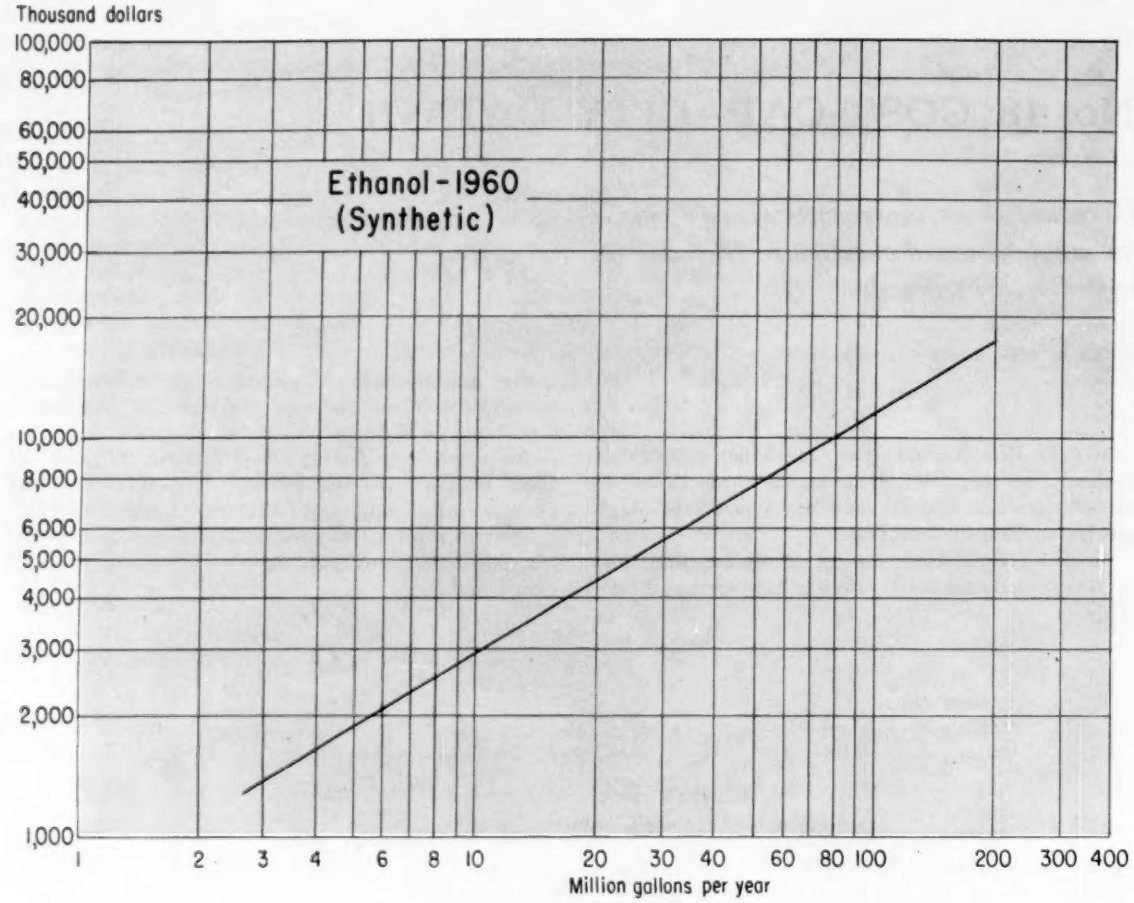
In Cost File No. 46 (Dec. 12, 1960, p. 172) we presented cost-capacity data, in the form of curves, for ethylene and two ethylene-based polymers—high- and low-pressure polyethylene.

Now we present cost-capacity curves for three more ethylene-based chemicals: ethylene oxide, ethanol (synthetic) and styrene. As before, where sufficient data were available, we indicate the high and low limits that might be expected.

Capacity power factors (Cost File No. 29, Apr. 18, 1960, p. 194) are respectively, 0.78, 0.60 and 0.68 Data are up to date as of the third quarter of 1960.

We will continue to present investment-cost, plant-capacity data correlations for other processes in future Cost Files.




Thousand dollars
100,000
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60,000
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8,000
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5,000
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3,000
2,000
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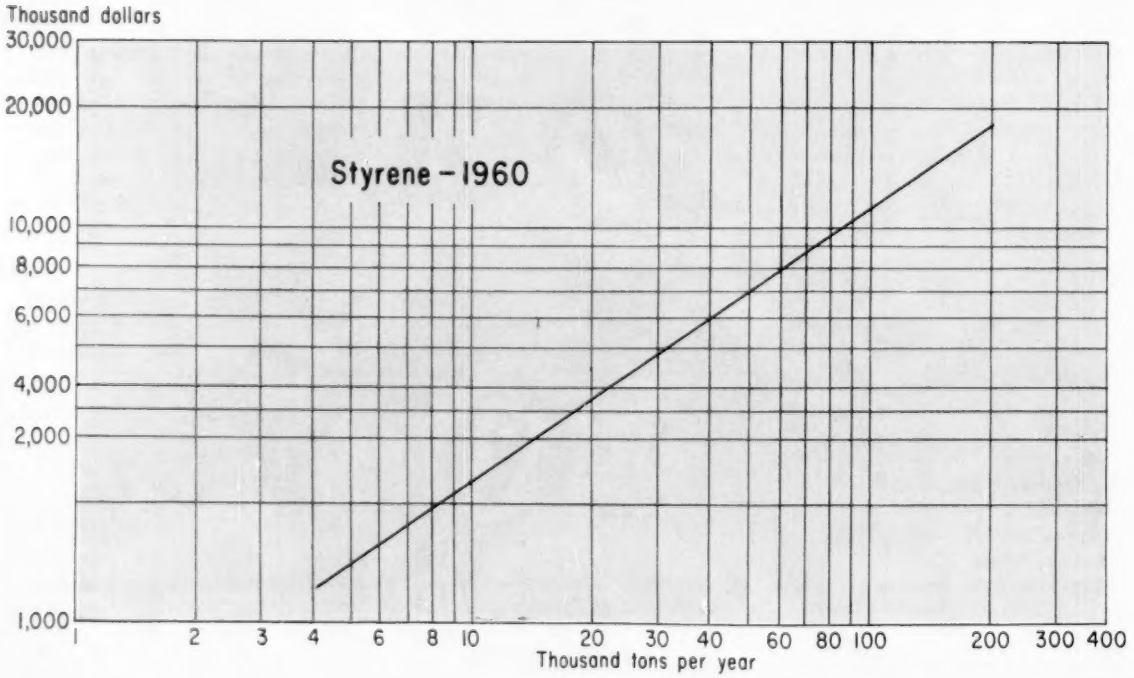
Ethanol - 1960
(Synthetic)
1
2
3
4
6
8
10
20
30
40
60
80
100
200
300
400
Million gallons per year


Thousand dollars
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Styrene - 1960
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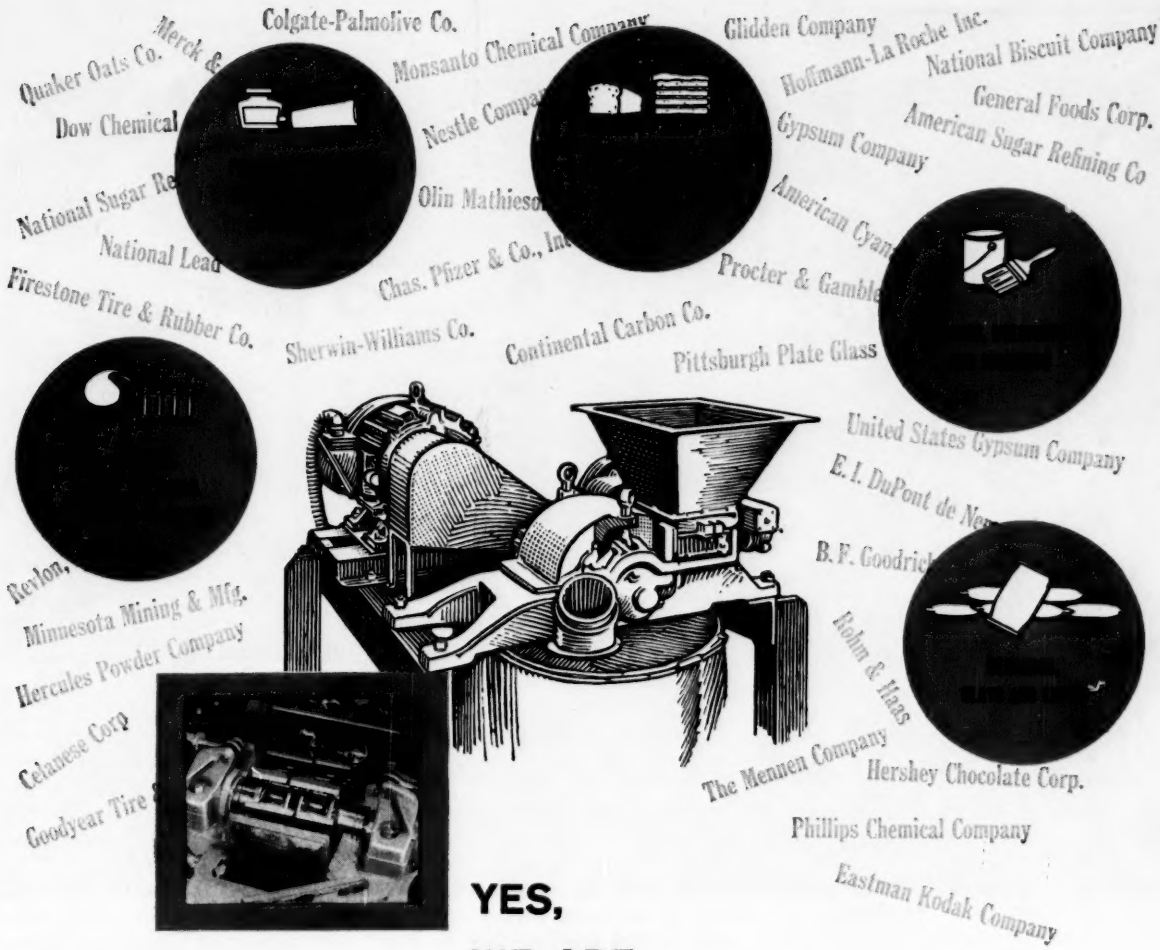
100
200
300
400
Thousand tons per year

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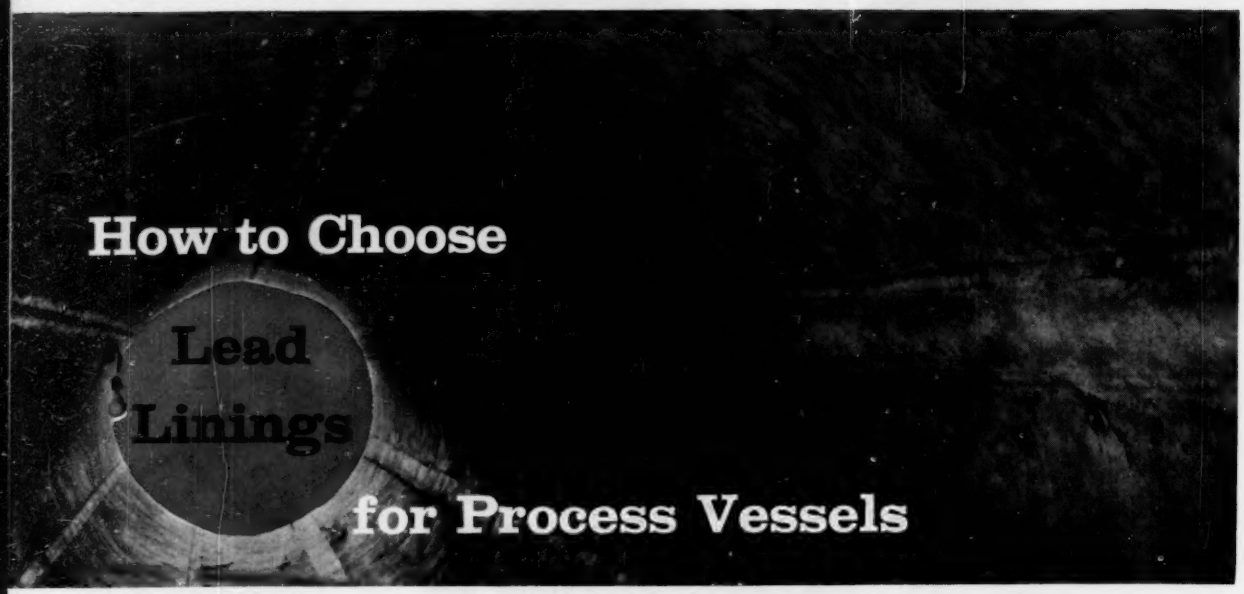


# How to Choose Lead Linings for Process Vessels

***There are five ways to line a vessel with lead—each has advantages and limitations. Choice is made based on lead's properties and operating conditions in the vessel.***

ROBERT L. ZIEGFELD
*Lead Industries Assn.*

Lead is an obvious choice for lining many reaction and storage vessels, particularly where severe corrosives must be contained. But specifying the correct type of lead for an application is only part of the job. To avoid costly and premature failures, the type of lining construction should also be selected by the design engineer.

This selection must be based on an understanding of lead's chemical and physical properties—and how they relate to the corrosive and to stresses that will develop in the operating vessel.

▶**Types of Construction**—There are five basic types of construction used for installing lead linings in chemical-processing vessels.*

Lead lining may be loose sheets of lead draped inside a shell of steel, wood, or concrete, with lead burned along the seams that are with or without internal supports of lead-covered steel; as sheets of lead and steel or lead and copper continuously bonded together face to face (commonly referred to as homogenously bonded); as a lining shell of sheet lead externally supported by a cage construction; or as a membrane that envelopes an acid-brick lining.

Loose lead-sheet construction is the least expensive but it is limited in practical application to vessels of moderate size and conditions that do not impose extremes of temperature, abrasion, pressure or vacuum.

The theoretical maximum length of a lead sheet, of uniform cross section supported only from the top, is 40 ft., at 68 F. In practice, however, it is seldom feasible to suspend lead sheet more than about 10 ft. without strapping. And excessive strapping requirements tend to offset the economies of this method.

However, new methods for fastening strappings reduce time and cost for this operation by 70%. Studs may be driven home with a power tool, which eliminates drilling and lining up bolt holes prior to fastening.

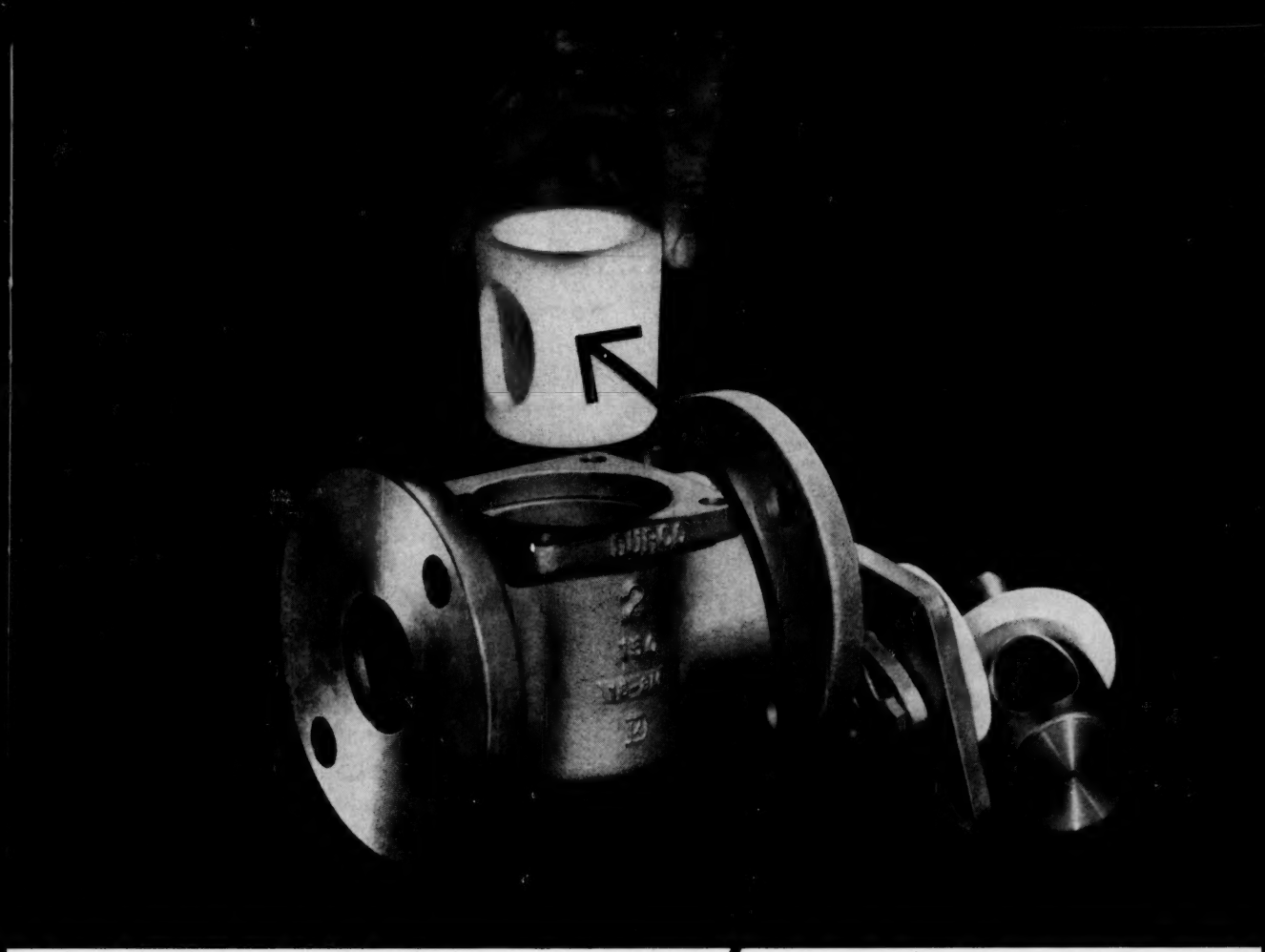
▶**Caged Lead**—Cage construction consists of an open exterior framework of steel flats and angles welded together to support the lead lining. Supporting members are spaced closer together toward the bottom to accommodate increased hydrostatic pressure. (Expanding and contracting lead lining is free to slip into stress-free posture within its rigid cage.) Open construction allows for excellent heat exchange, while leaks are readily seen and repairs easily made. Cost is low, comparable to that of loose sheet lining.

An ingenious example of cage construction that makes the most of heat-transfer possibilities is the Mills-Packard tower, designed as a reaction chamber for manufacture of sulfuric acid by the chamber process. The tower is tapered so that excess heat generated inside is dissipated by a film of water that flows down the exterior surface.

▶**Bond for Vacuum**—Homogeneously bonded sheets are usually lead on steel or lead on copper, although other combinations are possible. Steel provides strength; copper has desirable thermal properties.

Steel is cleaned by shot blasting or sometimes by pickling in 10% sulfuric acid. Copper is also chemically cleaned. Lead is then applied by a burning bar or, for larger

* Photo above shows lead-lined fume duct. Sheet-lead strip covers steel stud fastened to the vessel shell. Strip is burned to the lead lining.



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**Costs, conditions, requirements for five types of lead linings—Table I**

| | Loose Sheet | Steel Bonded | Copper Bonded | Cage | Brick |
|---|---|---|---|---|---|
| **Cost factors** | | | | | |
| Initial | Low | Fairly high | Fairly high | Low | Fairly high |
| Inspection | Low | Fairly high | Fairly high | Very low | Fairly high |
| Repair | Low | Low | Low | Low | High |
| **Hostile conditions** | | | | | |
| High temperature | Fair | Excellent | Excellent | Poor | Excellent |
| Thermal shock | Fair | Excellent | Excellent | Poor | Excellent |
| High pressure | Excellent | Excellent | Good | Poor | Excellent |
| Vacuum | Poor | Excellent | Good | Poor | Good |
| Physical shock | Poor | Excellent | Excellent | Poor | Good |
| Erosion | Poor | Fair | Fair | Poor | Excellent |
| Corrosion | Excellent | Excellent | Excellent | Excellent | Excellent |
| **Design requirements** | | | | | |
| Insulation | Fair | Fair | Poor | Poor | Excellent |
| Heat transfer | Excellent | Excellent | Excellent | Excellent | Poor |

areas, simply poured over the other metal. The lining surface is smoothed by peening and/or scraping.

Bonded linings are, of course, more expensive but are superior on almost all counts and will usually remain serviceable much longer than other types. Since there is no air gap between the two metals, uniform heat exchange is good. Rigidity, particularly with a steel backing, permits operation under high vacuum. For lead bonded directly to steel, operating temperatures as high as 608 F. are permissible, and the lining won't creep or crawl up to 450 F. Rapid temperature fluctuations, mechanical shock, and vibration are tolerated. This type of construction is also recommended for very tall structures where heavy acid-brick lining would impose formidable stresses.

Design engineers are advised not to skimp on the weight of lead specified in bonded linings: cost of such linings is essentially that of the bonding process.

Modern techniques have largely overcome objections to the difficult job of locating imperfections in the bond. An unbonded area may be identified by a bubble that forms when the internal temperature is raised to 400-500 F. or, in a pressure vessel, when the internal pressure is raised to 680 psia. and suddenly released. Efficient sonar and radiation methods of inspection are also available.

▶ **Brick for Heat**—Sustained operation involving high temperature, erosive attack, and extremes of corrosive attack and thermal shock are best withstood with acid-brick construction. The brick lining, usually one or two courses, insulates not only the system as a whole but the enveloping lead membrane as well, permitting operation at interior temperatures well in excess of the melting point of lead.

Acid-brick and lead are functionally complementary to one another. Acid-brick is resistant to polar organic chemicals but is attacked by nonpolar organics, to which, however, lead is resistant. The total system tolerates the most severe corrosive attack, as, for instance, both acids and alkalis in the same vessel. However, brick spalls due to rapid temperature changes, sustained operation at extreme high temperature, or absorption of saturated solutions that crystallize on cooling. Best grades of acid-brick are intentionally made 3 to 4% porous for increased resistance to thermal shock. The impermeable lead membrane contains the seepage.

If extreme high temperatures are expected, a brick-lined vessel should be built on an elevation so air can circulate freely beneath it. Otherwise, prohibitive heat may build up deep in the vessel. Sufficient brick must be used to prevent surface temperature of the lead from exceeding 125 F. Bottom of the vessel should be dished if extreme pressure is a factor. Also, it is sometimes desirable to design the lining so elongation of the bricks will close the gap between brickwork and lead membrane, holding the lead under compression for greater support.

Asbestos paper is bonded to the lead with potassium silicate solution to prevent contact with sodium ions in acidproof or furan-resin cements. While asbestos is not required with sulfur-base cements, two or three layers of nonburn paper should be used to form a protective cushion against abrasion.

Some of the new inspection methods developed for bonded linings have been equally effective in simplifying maintenance of brick-lined vessels.

Table I provides a check list of the relative strong and weak points

## Leads's resistance to various chemicals—Table II*

**Excellent**

| | |
|---|---|
| Sulfuric acid (to 96%) | Dry ammonia gas |
| Rayon solutions | Dry chlorine |
| Superphosphates | Carbon dioxide |
| Aluminum sulfate | Dry oxygen |
| Sulfur dioxide | Sulfur trioxide |
| Sulfite liquor | Sodium chloride |
| Acetone | Magnesium sulfate |
| Alcohol | Calcium carbonate |
| Benzene | Sodium carbonate (dilute) |
| Toluene | Bisulfates (dilute) |
| Gasoline | Chromates (dilute) |
| Ether | Sulfates (dilute) |
| Phenol | Phosphates (dilute) |
| Pyridine | Boric acid |
| Urea | Salycilic acid |
| Chromic acid | Sulfurous acid |
| Oxalic-sulfuric acid | Tartaric acid |
| Phosphoric acid | |
| Acetylene | |

**Good**

| | |
|---|---|
| Chlorine bleach | Ammonium phosphate |
| Nitroglycerin | Sodium hydroxide (up to 30%) |
| Naphthalene | Potassium hydroxide (up to 30%) |
| Wet chlorine gas | Nitric acid (concentrated) |
| Wet ammonia gas | Hydrocyanic acid |
| Carbon tetrachloride | Hydrochloric acid (up to 20%) |
| Dry hydrogen chloride | Arsenic |
| Calcium chloride | |
| Fatty acids | |
| Sodium sulfide | |
| Ferrous chloride | |

**Fair**

| | |
|---|---|
| Hydrogen peroxide | Ammonium fluoride |
| Wet oxygen gas | Ammonium chloride (up to 10%) |
| Cold bromine gas | Calcium hydroxide |
| Sodium sulfite (up to 20%) | Ammonium hydroxide |
| Sodium hyposulfite | Tannic acid (conc.) |
| Sodium chlorite (dilute) | Hydrofluoric acid |
| Nitrates | Formic acid (conc.) |
| Carbonic acid | Acetic acid (glacial) |

**Poor**

| | |
|---|---|
| Hydrochloric acid (pickling strength) | Sulfuric acid (over 96%) |
| Magnesium chloride | Hydrochloric acid (over 20%) |

**Not Recommended**

| | |
|---|---|
| Chlorite bleach | Ferric chloride |
| Potassium permanganate | Nitric acid (dilute) |
| Nitrobenzene | Acetic acid (dilute) |
| Sodium hypochlorite | |

*Chemicals are listed according to severity of attack. Least severe is listed first. Lead is chemical grade.

of each of the five major types of lead-lined construction.

▶ **Composition Important Factor**—Aside from construction methods, composition of the lead itself may be varied to enhance certain properties.

Chemical-grade lead or acid-copper-grade lead, containing from 0.04 to 0.08% copper and from 0.002 to 0.02% silver, forms a protective film faster than pure lead. The film adheres firmly and resists abrasion.

Trace elements also increase lead's creep and fatigue strength. Maximum allowable fiber stress at room temperature is 200 psi. Usefulness is limited to temperatures up to about 446 F. A 25 to 35% sulfuric acid solution will form a complete sulfate film on this grade in from 9 to 10 hr. at 70 F.

▶ **Antimony-Pb for Valves**—Lead containing 4 to 12% antimony is preferred for valves, pumps and other components requiring a certain degree of dimensional precision. This grade has greater hardness, rigidity, mechanical strength, and resistance to erosion and abrasion at ordinary temperatures. In addition, it creeps and warps less than pure lead.

However, antimonial lead is only advantageous up to about 248 F., because it softens rapidly at higher temperatures. At these higher temperatures, its mechanical strength is only equal to that of chemical-grade lead.

Moreover, antimony lowers lead's chemical resistance. Antimonial lead is preferred for handling sulfuric acid only in very low concentrations (optimum resistance with 3% antimony). Maximum allowable fiber stress of antimonial lead is 400 psi. at room temperature. A complete sulfate film is formed on antimonial lead by 25 to 35% sulfuric acid in from 1 to 1½ hr., at 70 F.

Resistance to metal fatigue is promoted by addition of 0.04 to 0.05% tellurium to the lead. Tellurium acts as an inhibitor of grain growth and also makes the lead amenable to work hardening.

▶ **Corrosion Resistance**—And, of course, lead's corrosion resistance must be considered in any lining installation.

As with aluminum and stainless steel, lead's resistance to chemical attack is based not on its chemical inertness but rather on its chemical reactivity. Lead reacts very quickly with most corrosive agents to produce resistant, insoluble salts that form nonporous protective films over the pure metal. It is this film, not the metal itself, that resists further attack.

Lead is highly recommended for handling sulfuric acid under most conditions. This acid reacts with the metal to form an adherent, impermeable film of lead sulfate that guards the metal against further attack. In acid concentrations up to 96%, corrosion of lead is negligible at room temperature. In stronger concentrations, acid apparently reacts with the film.

Nitric acid presents a more complex situation. Dilute nitric combines with lead to produce lead nitrate, which adheres poorly to the metallic surface and is somewhat soluble in the dilute acid. Lead is, therefore, not recommended for handling dilute nitric. But concentrations from 52 to 70% by weight do little damage to lead vessels. This is, apparently, because solubility of lead nitrate in nitric acid decreases as concentration of the acid increases (Fig. 1).

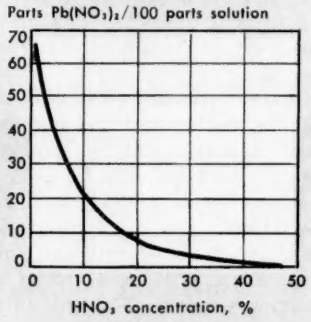
Dissolved gases, particularly oxygen, may affect rate of corrosion substantially. Corrosion rates of lead in distilled water at 77 F. vary directly with the oxygen content of the atmosphere above the liquid.

▶ **Acid Bath Protects**—The corrosion pattern observed at a typical sulfuric acid plant illustrates the effect of oxygen in the vapor phase and suggests a useful protective technique.

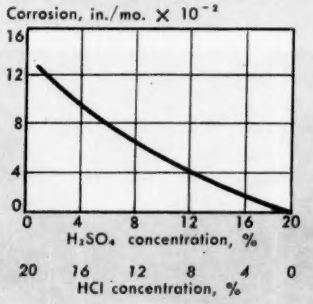
Where the liquid acid was in contact with a lead lining, the lining was perfectly protected by a film of sulfate salts formed by reaction of the metal and the acid. However, severe corrosion was observed higher on the walls of the vessel where the lining was in contact with the vapor phase. The reaction products formed in the presence of free oxygen in the vapor phase were unstable and formed an inadequate film.

One solution to this problem was to maintain the liquid level at the top of the vessel or periodically to

**Lead nitrate dissolves in nitric acid—Fig. 1**




**Lead corrodes in mixed acids—Fig. 2**




raise it to the top long enough to renew the impermeable film.

This suggests the following method of pretreating lead for use in contact with corrosives that do not form an impermeable protective film: fill the lead-lined vessel with 25 to 35% sulfuric acid and maintain temperature at 70 F. This will form a complete sulfate film on chemical-grade lead in 9 to 10 hr. Only 1 to 1½ hr. is required to achieve the same effect on 9% antimonial lead.

▶**Additive Effects**—In general, while lead is highly resistant to corrosives that form insoluble sulfates or phosphates, it does not perform too well under attack by solutions that form soluble nitrates, acetates or chlorides.

Also, effect of attack by a mixture of corrosives is additive. For example, lead is protected by sulfuric acid, corroded by hydrochloric acid. Resistance varies linearly as the ratio of sulfuric to hydrochloric in a mixture of acids (Fig. 2).

This, of course, assumes no complications involving products of the reaction between lead and the separate solutions, or between one solution and another. In such cases, effects of the intermediate and final products must be considered independently.

Table II classifies resistance of lead to many of the chemicals commonly handled in the chemical processing industry. Performance in a particular application will depend, in addition, on temperature, erosion, and mechanical abuse. In most cases, corrosion increases with increase in temperature.

▶**Watch Erosion Effect**—Erosion may become an important factor when the solution is agitated or flowing through the vessel. While it is true that lead's corrosion resistance is essentially "self healing," it should be remembered that formation of the protective salt film consumes lead. If the film is constantly eroded and replaced, lead will be consumed progressively. Factors that determine rate of erosion include rate of flow and entrainment of particulate matter.

The relationship between rate of flow and rate of erosion may not be linear. For example, in laboratory tests, for 20% sulfuric acid at 77 F., the following is true for chemical-grade lead.

| Flow Velocity (Ft./Min.) | Corrosion Rate (In./Mo.) |
|---|---|
| 8.4 | 0.00055 |
| 97 | 0.00017 |
| 155 | 0.00016 |
| 300 | 0.00086 |

Mechanical abuse may, of course, contribute to corrosion more than erosive attack. Design and operating procedures should minimize any mechanical damage.

▶**Smooth as Glass**—Due to its malleability, lead presents an uncommonly smooth surface—one reason why it is often chosen for process equipment. Smoothness of the interior surface of extruded lead pipe is rated about even with glass.

Aside from its softness and malleability, the more pertinent mechanical properties of lead are its coefficient of expansion (about 16.3 x $10^{-6}$/F.), its melting point (620 F.) and its density (0.410 lb./cu. in.). In absence of stress-corrosion conditions, it is safe to use lead up to about 446 F.

Related to these physical characteristics are two factors that should be kept in mind when making comparisons of lead versus other materials. Such comparisons usually are based either on mass lost to corrosion per unit time, or depth of penetration of corrosion per unit time. But loss of material of a given mass is relatively insignificant in the case of lead, since lead is so heavy. And a given depth of penetration is not as serious in a lead lining, as a rule, since lead linings are ordinarily much thicker than those of other materials.

Finally, economic considerations favor lead. It is inexpensive and easy to work. And scrap recovery usually rebates about 50% of original material cost.

## Meet the Author

**ROBERT L. ZIEGFELD** *is secretary and treasurer of the Lead Industries Assn., New York, N. Y. He is the author of many articles, both technical and economic, on the production and application of lead.*

*From 1947 to 1956, he also served as secretary and treasurer of the Metal Powder Assn. He is presently a member of AIME, ASTM, IM (British).*

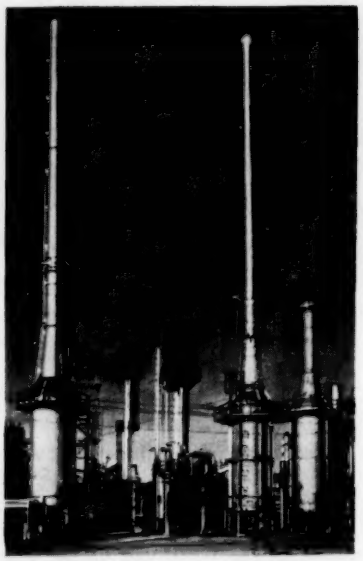
*A 1925 graduate of the Sheffield Scientific School of Yale University, with a B.S. in mining engineering, he practiced this profession in South Africa and Minnesota.*

CPI NEWS BRIEFS . . .

*(continued from page 92)*

facilities, will cost about $9.3 million, and the new unit will permit Sun to shut down two gas plants that went on stream before World War II.

Charge streams to the unit will include liquids and gas mixtures from nearby catalytic cracking plants. Products will be used as gasoline blending stock, fuel gas, alkylation and polymerization feed, and feed to propylene splitting. Plant will have initial capacity to separate 14.4 million cu. ft. dry gas, 7,100 bbl. liquefied propane and propylene, 13,200 bbl. liquefied butane and 18,000 bbl. gasoline per day.



**Texaco Inc.** has placed a hydrotreater, above, on stream at its refinery at Casper, Wyo. Company did its own process engineering for the project; construction, detail engineering and purchasing were done by Badger Mfg. Co., Cambridge, Mass.

**American Potash & Chemical Corp.** and **Laporte Industries Ltd.** are entering into a joint operation to make titanium dioxide on the West Coast. Latter firm, a producer of titanium pigments in the United Kingdom, will supply process information and know-how; American Potash will construct

and operate the facilities and will own 85% of the enterprise. The manufacturing facilities, to be erected at an undisclosed location, will cost about $15 million, will have initial capacity of 25,000 tons/yr. Production is scheduled to start in the second half of 1962.

**Swift & Co.'s** Technical Products Dept. has begun a major addition to its epoxidation plant at Hammond, Ind. Scheduled for operation early this year, it will add 8 million lb./yd. to the plant's present capacity for epoxidized oils and fatty esters, will permit Swift to turn out a complete line of these products.

**Stauffer Chemical Co.'s** Consolidated Chemical Industries Div. is building a liquid aluminum sulfate plant on a 172-acre tract at Counce, Tenn. It will be adjacent to a new paper mill of Tennessee Pulp & Paper Co., and is scheduled to go on stream around February 1. It will be Stauffer's first alum plant in the Southeast; the firm operates seven other alum plants that serve the Southwest and West.

**Keyes Fibre Co.,** producer of molded pulp products, will build a plant in Sacramento, Calif., to make all the firm's major product lines. Company currently has plants in Hammond, Ind., and Waterville and Fairfield, Me., as well as a pulp mill in Fairfield.

## *Offices*

**Beckman Instruments, Inc.'s** Scientific & Process Instruments Div. has opened a sales office in Cambridge, Mass. Firm's headquarters are in Fullerton, Calif.

## *Companies*

**Humble Oil & Refining Co.,** Houston, domestic-operations affiliate of Standard Oil Co. (N. J.), has

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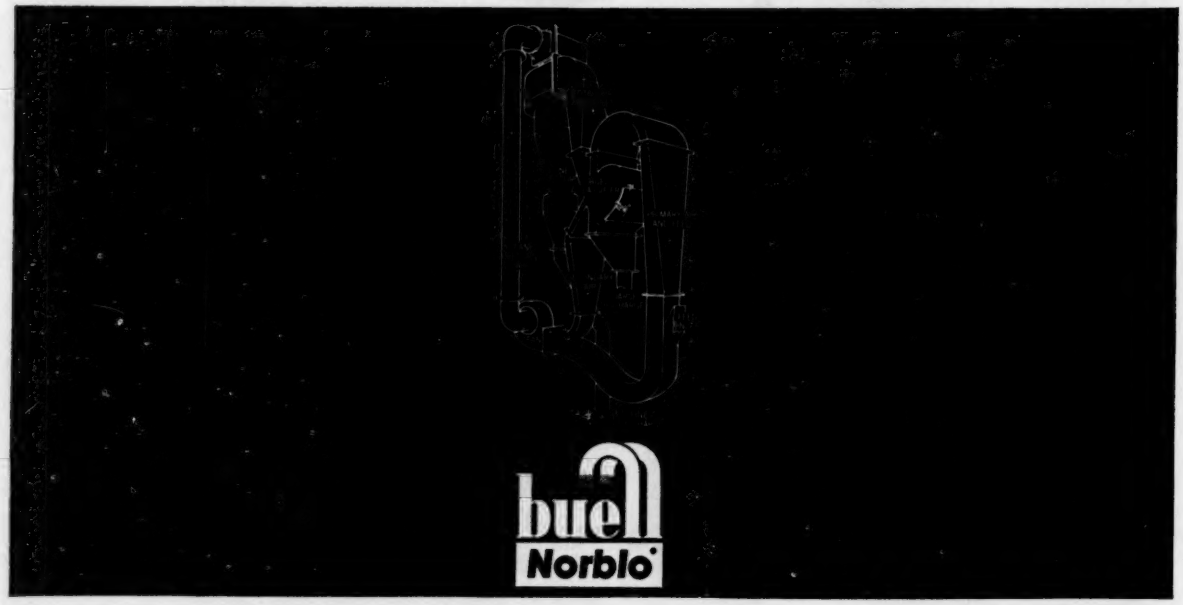
**A sodium phosphate manufacturer had to meet stricter customer specifications. No more than 15% of the material could be below 100 mesh and no more than 1% below 270 mesh. But the apparent density could not be less than 0.98. If the classifier removed too much of the intermediate size particles from the finished product, the apparent density requirement could not be met. ■ Laboratory tests proved that the Buell Classifier could easily meet the mesh requirements, and the required apparent density could be maintained if the classification was at 95% overall efficiency. The Buell Classifier simply discharged the coarse sodium phosphate by gravity into one bin and carried the fine material by air to a second bin. ■ Despite rigid particle-size requirements, Buell Air Classifying Systems operate to critical size specification at well over 90% efficiency. High capacities let them keep up with all mills. And with low velocity and no moving parts, wear is almost non-existent. ■ Buell Classifiers today are being used in iron ore beneficiation, removal of minus 10 micron sodium nitrate particles, dedusting of soda ash and the classification of such diverse materials as phosphate rock, silicon carbide, uranium ore and glass beads. Many installations have proved so successful that they have led to repeat orders. Why not send us your specific problem? Write for descriptive literature. The Buell Engineering Co., Inc., Dept. 12-A 123 William St., New York 38, N. Y. Northern Blower Division, 6420 Barberton Ave., Cleveland, Ohio. (Subsidiary: Ambuco, Ltd., London, England) ■ Cyclones • Electric Precipitators • Bag Collectors • Combination Systems • Classifiers**



announced a long-range plan aimed at reorganizing its operations and streamlining its management. Main feature is the establishment of four operating regions in the U. S. for exploration, production and marketing, with headquarters at New York, Tulsa, Houston and New Orleans.

In addition to this geographical organization, Humble will have three functional divisions: a Manufacturing Div., a Marine Div., and the Enjay Chemical Co.

The firm's general headquarters will continue to be in Houston. The new plan has already become effective in principle and will be implemented as quickly as operations permit. When it is completely in effect, Humble's present operating divisions such as Carter and Esso Standard will cease to exist.

**Pfaudler Permutit Inc.,** Rochester, N. Y., has formed a new Brazilian company called Pfaudler Permutit Beneficiamento de Fluidas, Ltda. Headquartered at Sao Paulo, it will be primarily concerned with engineering, subcontracting and importing Permutit water-conditioning equipment for the Brazilian market. Also, it will investigate the desirability of establishing facilities to make plastic or glass-lined vessels in that country.

**Stauffer Chemical Co.,** New York, and **Hewitt-Robins Inc.,** Stamford, Conn., plan to form a joint company, Stauffer-Hewitt, Inc., to manufacture and sell polyurethane foam materials. The new firm will purchase the assets of Hewitt-Robins' Urethane Foam Div., which has headquarters and a manufacturing plant at Franklin, N. J.

## *International*

**Italy:** A joint-venture firm, Noury-Rumianca Sp.A., has been formed between the Dutch company Noury & Van der Lande and Italy's chemical works Rumianca Sp.A. The venture will result in a new,

CPI NEWS BRIEFS . . .

3,000-ton/yr. citric acid plant at Avenza, which is scheduled to start production by the end of this year. This will be the second Italian plant associated with the Dutch firm; the first is Noury Italia, at Mornago.

**Australia:** Swift & Borden Chemical Co., Pty. Ltd., is building a $250,000 formaldehyde plant in Sydney. It will have capacity of 13 million lb./yr., and about 70% of output will be used captively. Swift & Borden is an affiliate of Borden Chemical Co., New York; it currently operates a plant in Sydney that produces resins and caesin adhesives.

**Iran's** government has contracted with Kaiser Engineers & Constructors, Inc., Oakland, Calif., for help in planning and implementing a steel-facilities project proposed for that country. An importer of steel in the past, Iran has been working since shortly after World War II on a program to stimulate its over-all industrial growth.

**West Germany:** Smith, Kline & French Laboratories, Philadelphia, and the German firm Rohm und Haas GmbH., Darmstadt, have jointly formed a subsidiary called Rohm und Haas Pharma GmbH., with basic capital of $240,000. Headquartered in Darmstadt, the firm will handle the pharmaceutical business of the German parent company (which produces mainly plastics), and will act as sales representative for Smith, Kline & French in the German and Austrian markets.

**Japan:** Perkin-Elmer Corp., Norwalk, Conn., and Hitachi, Ltd., Tokyo, have agreed to establish a jointly owned company to handle scientific instruments. Firm will be called Hitachi Perkin-Elmer, Ltd.; it will conduct research, development, manufacture and sales throughout the free world. Hitachi is described as Japan's largest industrial company—it manufactures a wide range of products, including power plant, railroad, electrical and electronic equipment.

## *Convention Calendar*

**January**

**23-26.** 12th Annual Plant Maintenance & Engineering Show, International Amphitheatre, Chicago, Ill.

**24-27.** Society of Plastics Engineers, Annual Technical Conference, Shoreham and Park-Sheraton Hotels, Washington, D. C.

**24-27.** Canadian Pulp and Paper Assn., 1961 Annual Meeting of the Technical Section, Queen Elizabeth Hotel, Montreal, Que.

**30-9.** University of Illinois, Quality Control by Statistical Methods, Urbana, Ill.

**February**

**5-10.** National Petroleum Assn., Symposium on Research on Gasoline, Benjamin Franklin Hotel, Philadelphia, Pa.

**7-9.** The Society of the Plastics Industry, Inc., 16th Reinforced Plastics Division Conference, Edgewater Beach Hotel, Chicago, Ill.

**13-16.** American Society of Heating, Refrigerating and Air-Conditioning Engineers, 15th International Heating & Air-Conditioning Exposition, Chicago Amphitheatre, Chicago, Ill.

**13-17.** American Management Assn., Inc., Packaging Management Course, Hotel Astor, New York, N. Y.

**16-17.** American Society for Metals (Albuquerque and Los Alamos Chapters), Symposium on Recent Developments in Materials for Nuclear Applications, University of New Mexico, Albuquerque, N. M.

**20-23.** Technical Assn. of the Pulp and Paper Industry, 46th Annual Meeting, Hotel Commodore, New York, N. Y.

**26-2.** Society of Petroleum Engineers of the American Institute of Mechanical Engineers, Annual Meeting, Chase & Park Plaza Hotels, St. Louis, Mo.

**26-1.** American Institute of Chemical Engineers, Petroleum and Petrochemical Exposition, National Meeting, Municipal Auditorium, New Orleans, La.

**March**

**13-17.** National Assn. of Corrosion Engineers, Annual Conference & Corrosion Show, Statler Hotel, Buffalo, N. Y.

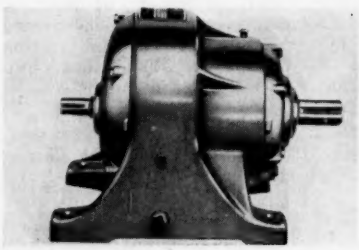
MORE NEW EQUIPMENT . . .

*(continued from page 104)*

12 in., 33 lb.), the unit is connected to cold water and steam lines. Mixing is direct, quiet, efficient—delivering 40% more hot water per lb. of steam than conventional direct heaters. "Practically 100%" thermal efficiency is claimed; and since input steam becomes additional hot water, no return system is necessary. Steam is used only when hot water is drawn.

Industrial applications are indicated where steam is available but hot water would have to be piped a long distance. For example, the unit has potential uses in chemical solution preheating, plastic extruding, booster heating for rinses, or for shower facilities in remote areas.

Unit has no gaskets, coils or moving parts to wear out, does not rust.—**Conant Bros. Co., Medford, Mass.** **104C**



## Speed reducer

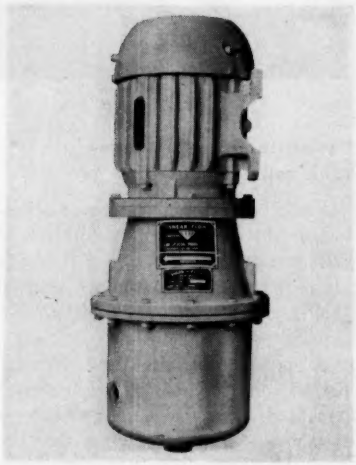
**Compact model steps down rpm. for low speeds, high torques.**

This double-reduction type speed reducer features an improved lubrication system, a minimum of working parts, and an arrangement of pinions and fully-hardened, helical gears which eliminate gear breakage caused by heavy-duty loads. Providing maximum speed reduction in high-torque, low-speed operations, models come in a broad range of capacities: ⅓ to 75 hp., ratios from 5.00 to 47.4.

The reducers are driven by a separate, direct-connected motor. Connection is through a one-piece

cast-iron housing, normalized to prevent warping, which eliminates the usual misalignment problems and muffles the noise as well. A direct connection may also be made on the take-off shaft, or an indirect connection through V-belts or chain drives. Motor-reversal protection is available in an optional non-reverse backstop.

The lubrication system includes a positive oil seal, which prevents leakage in the high-speed input shaft, and dip lubrication, which permits the addition of precise amounts of lubricant at all speeds in either direction.—**The McCarty Co., Los Angeles.** **176A**



## Continuous mixer

**Sealed unit mixes any liquid that normally can be pumped.**

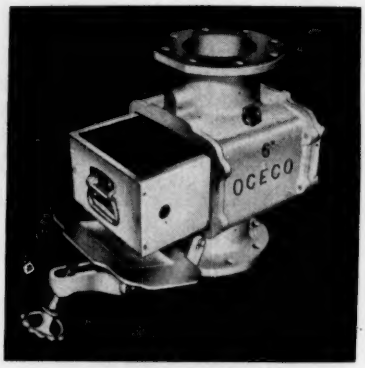
Designed to provide high shear action in continuous mixing operations, a new mixer has its mixing head enclosed within a sealed chamber that contains an inlet for introduction of material and an outlet for the passage of finished mixture.

Sealed unit eliminates air entrainment, works well on pressure systems, also for inversion applications, introduction of gases to liquids, and handling flammable materials safely.

Although small in size, new unit is said to handle high-viscosity materials in a minimum of time, providing complete recirculation

NEW EQUIPMENT . . .

and thorough blending, homogenizing, emulsifying or dispersing. Motors ranging from 1 to 10 hp. drive the mixing head.—**Gabb Special Products, Inc., Windsor Locks, Conn.** 177A




## Dehydrator

**Desiccator dries storage-tank replacement air.**

Basket-drawer desiccator prevents dilution and contamination of tank contents by adsorbing the inlet air moisture, as product is removed from, and replacement air drawn into, any storage tank.

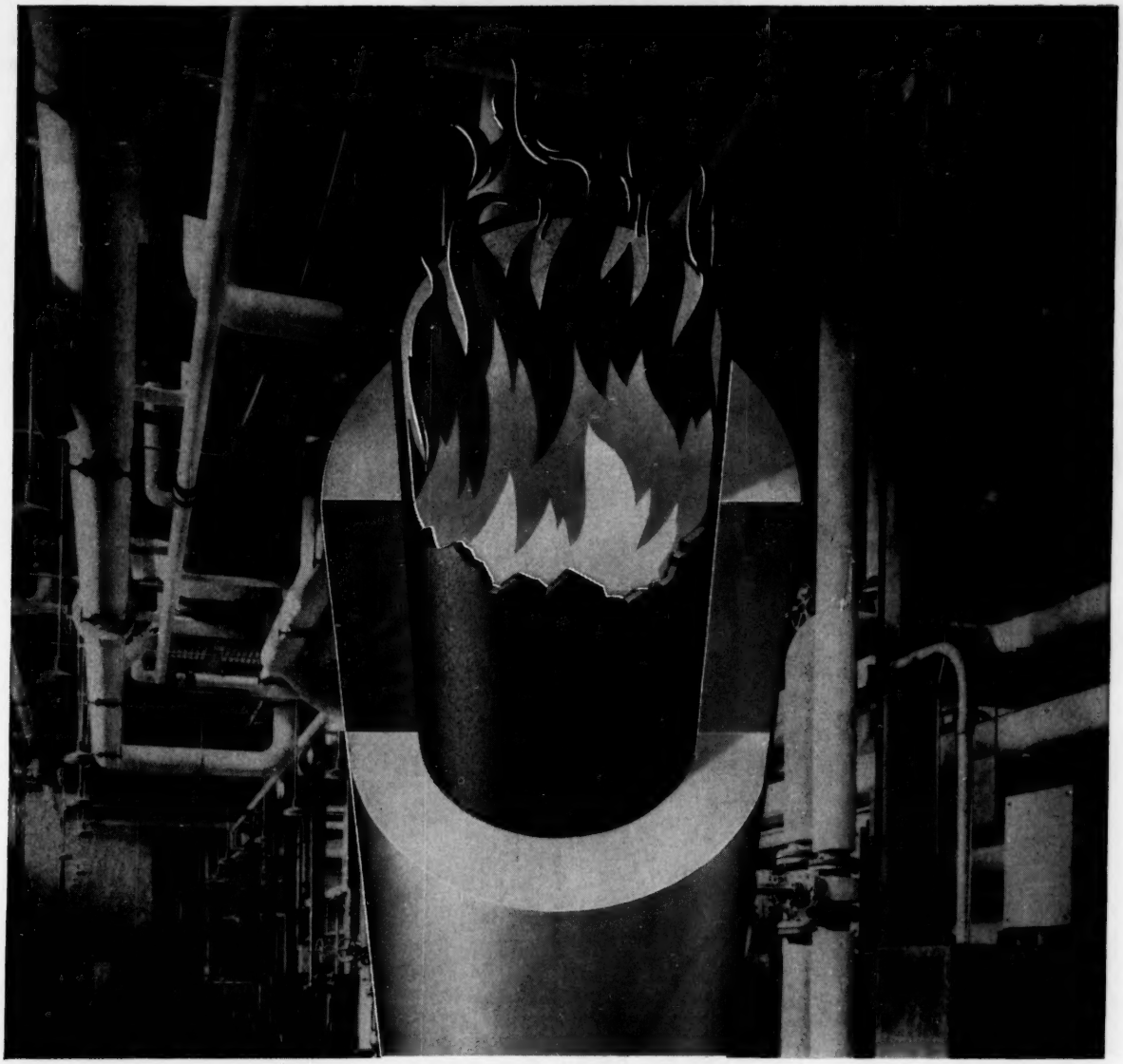
A layer of indicator material, placed on top of the wire-mesh basket drawer, is clearly visible as it turns from blue (when dry) to pink (wetter) and finally to white (saturated). Average life of a desiccant drawer ranges from 30 to 100 days, depending on the humidity of the air and its inlet frequency.

Mounted between the roof collar and vacuum relief vent, the dehydrator unit comes in seven sizes ranging from 2 to 12 in.—**The Johnston & Jennings Co., New York.** 178A

## High-temperature torch

**Need something heated as high as 50,000 F.? Try this device.**

Plasma torch attains ultrahigh temperatures (from 5,000 to 50,000 F.), ultrahigh enthalpies (up to 60,000 Btu./lb.), does both with



# NEW CALSILITE-HI® HANDLES SOAKING 1800°F

Light, strong and economical, new Calsilite-Hi is ideal for both insulation and fireproofing where temperatures run over 1250°F up to 1800°F. For lower temperatures than these, Ruberoid's Regular Calsilite® insulation is recommended.

Both Calsilite and new Calsilite-Hi are molded calcium silicate insulation. They're light and easy to install. They cut and mitre quickly, smoothly. They're gentle on hands. They stay strong when wet, won't soften or fall off, return to original thermal efficiency when dry. They resist most industrial chemicals and alkalies. Available in half sectional, three segmental and block form.

For additional information, specifications, and free samples of new Calsilite-Hi or regular Calsilite insulation, mail coupon now.

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flame momentum one half that of an oxy-acetylene welding flame.

Nozzle pressure is 1 atm., so direct impingement of the plasma flame on a molten surface stirs no appreciable surface disturbance. The flame itself is needle-shaped, with heat distributed evenly throughout its length. And the torch is silent.

Applications include: spheroidizing, thermochemical reactions, crystal growing, welding and piercing. Company is presently exploring a number of new processes suggested by the torch.—**Thermal Dynamics Corp., Lebanon, N. H.** **178B**

## *Briefs*

**Seal ring assembly** that can seal off differential pressures of up to 50,000 psi., comes in all ranges of "O" ring diameters from less than ¼ in. to many feet. Assembly's non-extrusion ring absorbs dimensional changes in equipment, preventing extrusion of "O" ring.—**Bowen Itco, Inc., Houston.** **180A**

**Drum warmer** is two semicylindrical sections of single-embossed heat-transfer panels. Sized to accept 55-gal. drums, unit holds drum horizontally, leaves center and end bungs free. Hot water, steam (or refrigerant) may be introduced by separate piping at pressure ranging up to 125 psi.—**Dean Products, Inc., Brooklyn, N. Y.** **180B**

**Seamless small diameter tubing** contains 42% Ni, 21% Cr. small amounts of Mo and Cu. It has good resistance to hot sulfurous and phosphoric acid solutions, is said to resist better than stainless steel pitting by sea water and stress-corrosion cracking in chloride solutions.—**Superior Tube Co., Norristown, Pa.** **180C**

**Corrugated pallet,** weighing only 3-4 lb., can carry strapped loads as

heavy as 10,000 lb. In flattened form for shipping, ten units occupy the space needed by conventional wooden pallet; one man with staple gun can assemble pallet at point of use. Leg design permits 4-way entry by fork-lift trucks. — **Packaging Corp. of America, Evanston, Ill. 180D**

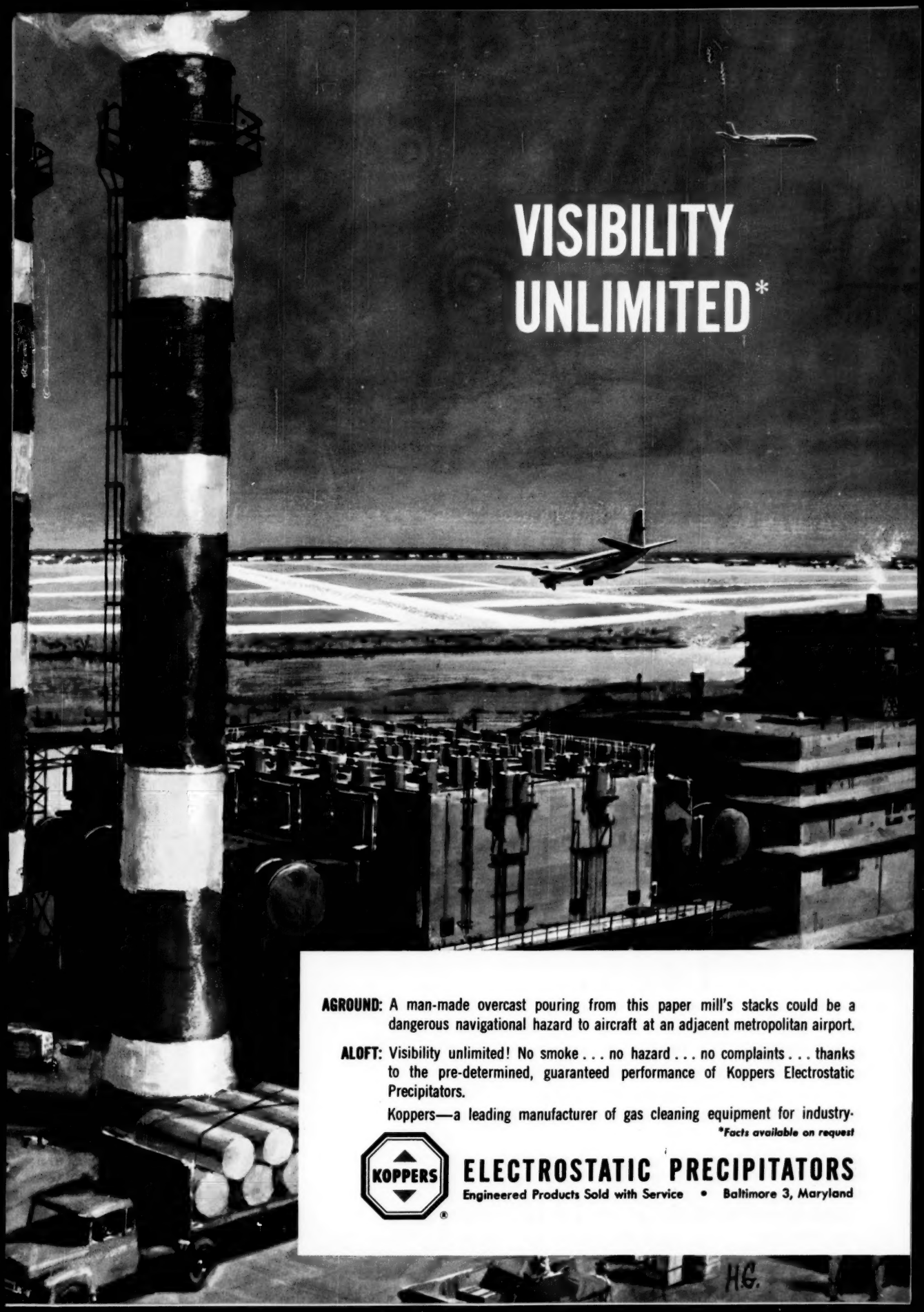
**Eye-wash fountain,** designed in modern style, has large push-type operating valve that blinded user can find quickly without fumbling. Separate flow-control valve assures proper water volume and pressure. Once operated, fountain flows until the valve is manually closed.—**Haws Drinking Faucet Co., Berkeley, Calif. 182A**

**Solid-state digital computer** is said to be useful to engineers and scientists in small to medium-sized plants. Desk-size unit has floating point hardware as optional feature. Functional computer module detaches from desk portion for process control uses.—**Autonetics Div. of North American Aviation, Inc., Downey, Calif. 182B**

## Equipment Cost Indexes . . .

| | June 1960 | Sept. 1960 |
|---|---|---|
| **Industry** | | |
| Avg. of all | 238.2 | 237.4 |
| **Process Industries** | | |
| Cement mfg. | 232.8 | 231.7 |
| Chemical | 240.1 | 238.6 |
| Clay products | 226.2 | 225.6 |
| Glass mfg. | 226.6 | 225.3 |
| Paint mfg. | 229.8 | 229.1 |
| Paper mfg. | 231.3 | 229.9 |
| Petroleum ind. | 234.1 | 234.0 |
| Rubber ind. | 237.6 | 236.9 |
| Process ind. avg. | 236.5 | 236.2 |
| **Related Industries** | | |
| Elec. Power equip. | 242.7 | 240.2 |
| Mining, milling | 241.5 | 240.0 |
| Refrigerating | 268.5 | 267.7 |
| Steam power | 225.0 | 224.3 |

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124–6 for method of obtaining index numbers; April 4, 1960, pp. 149-50 for annual averages since 1913.


VISIBILITY
UNLIMITED*
AGROUND: A man-made overcast pouring from this paper mill's stacks could be a dangerous navigational hazard to aircraft at an adjacent metropolitan airport.
ALOFT: Visibility unlimited! No smoke . . . no hazard . . . no complaints . . . thanks to the pre-determined, guaranteed performance of Koppers Electrostatic Precipitators.
Koppers—a leading manufacturer of gas cleaning equipment for industry.
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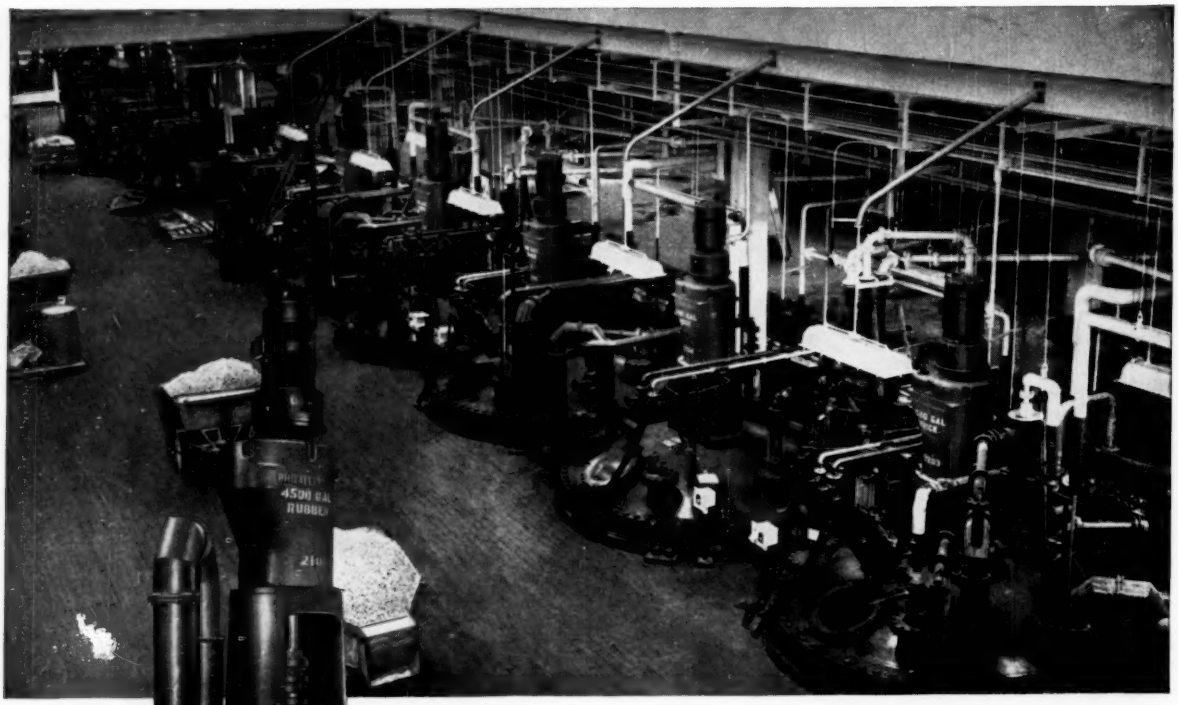
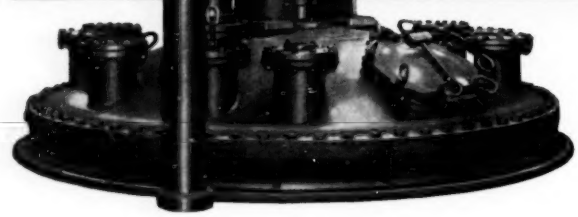
# YOU GET MORE...WHEN IT'S A PHILADELPHIA MIXER!





**YOU GET MORE** because Philadelphia Mixers are huskier. All components are heavier duty, higher capacity.

**YOU GET MORE** because the integrated design of Philadelphia Mixer drive assemblies makes optimum use of the high quality and extra capacity of all components. Result: Improved mixer performance . . . longer mixer life . . . reduced maintenance costs.

**CASE IN POINT:** Hundreds of Philadelphia Mixers installed at Toms River-Cincinnati Chemical Corporation, major producer of dyes, have produced solid, over-the-years savings through rock bottom maintenance costs and 100% availability. This includes mixers with horizontal motor drives that solve headroom problems . . . mixers with vertical motor drives that simplify tank top piping arrangements . . . mixers with variable speed drives that meet changing process needs . . . and special mixers with push button controlled impeller raising and lowering devices.

When you buy Philadelphia Mixers you get still another advantage . . . precision ground gearing in the mixer drives. This is a major advance in gear accuracy that means less wear, less vibration and reduced sound levels.

Look into all the advantages of Philadelphia Mixers. Six standard models, 1 to 250 HP. Special units to 500 HP. Horizontal or vertical motor drive. Mechanical seal or packed stuffing box. Paddle or turbine type impellers. For complete data, write for catalog A-19.

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# U.S.I. CHEMICAL NEWS

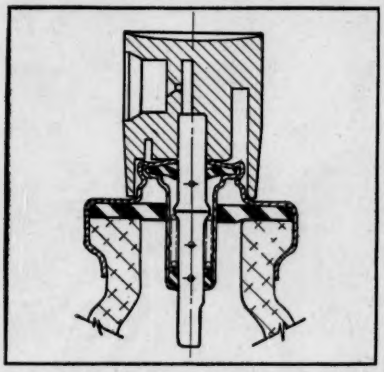
January ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1961

## New Filling Technique Spurs Use of Metered Valves for Aerosols

In recent months a practical, volume-production method has been developed for pressure-filling aerosol containers through metering valves. Advantages claimed for pressure-filling over cold-filling techniques for metered valves: water-based systems can be handled; no danger of chemical change caused by cooling. As a result, it is felt that the new technique will lead to more widespread use of metered aerosols, particularly for drugs and cosmetics.

A metering valve has two ports—inlet and outlet. When the actuating button is pressed, both ports are operated. The inlet port closes to shut off the product in the container. The outlet port opens to let the product trapped in the valve expand and

MORE



Cross-section of metered valve shows 2 lower ports for pressure filling. (Diagram courtesy of Emson Research)

## *New Data Sheet on Diethyl Carbonate Offered by U.S.I.*

Specifications, properties, commercial information, typical reactions and uses of diethyl carbonate are detailed in a new technical data sheet just released by U.S.I. The material is a medium evaporating nitrocellulose solvent having mild odor, good stability and extremely low acidity. It is considered as nearly neutral an ester solvent as it is possible to make.

Diethyl carbonate is also used as a solvent for synthetic and natural resins, and lacquers such as those required for coating the cathodes of radio tubes. The material is also employed for organic syntheses.

For a copy of the new data sheet, contact your nearest U.S.I. sales office or Technical Literature Dept., U.S.I. Chemical News, 99 Park Ave., New York 16, N. Y.

# U.S. Anhydrous Ammonia Production Up 10% in 1960

### Versatile Chemical Employed in Agriculture, and by Industry in Wide Range of Operations from Drug Manufacture to Explosives.

The U.S. Department of Commerce reports that in the first six months of 1960, 2.5 million short tons of synthetic anhydrous ammonia were produced in this country—10% more than in the same period in 1959. This increase brings production up 80% since 1954. It reflects the growing importance of the material, not only for fertilizer purposes, but for a wide range of industrial operations as well. Most important industrial uses include:

**Ammonia in Chemical Processes**

Ammonia is important in the production of pharmaceuticals such as sulfa drugs, vitamins, antimalarials, amino acids.

Petroleum refiners employ ammonia to neutralize acids in oil to protect equipment from corrosion. For this purpose it is low-cost, has a high diffusion rate in oil, and neutralizes acidity without forming water. Products of neutralization are easily eliminated and excess ammonia can be removed by aeration. It can be introduced into equipment by its own vapor pressure.

**Ammonia in Explosives**

The explosives industry is one of the largest industrial consumers of ammonia. Nearly all industrial and military explosives contain nitrogen derived from ammonia by way of nitric acid or amines.

**Ammonia in Textiles and Plastics**

Rayon makers use ammonia to produce ammoniacal copper hydroxide solutions for dissolving cotton linters. In nylon manufacture, it is a raw material for hexamethylenediamine. It also plays a part in making acrylonitrile fibers.

The plastics industry employs ammonia in producing urea formaldehyde resins, and for making hexamethylenetetramine—catalyst and pH control agent in production of phenol—and urea-formaldehydes.

**Ammonia in Pulp and Paper**

An increasingly important application for ammonia is its substitution for lime in bisulfite wood pulping. It is claimed that ammonium bisulfite produces pulp of better quality, greater yield, reduces steam consumption, and makes possible the use of some hardwoods previously considered unuseable. Conversion is inexpensive.

**Ammonia in Metal Working**

The most important use of ammonia here is in case hardening of steel by nitriding. Ammonia vapor is passed over steel parts in a furnace at 900° - 1,000°F. It dissociates, producing "active"

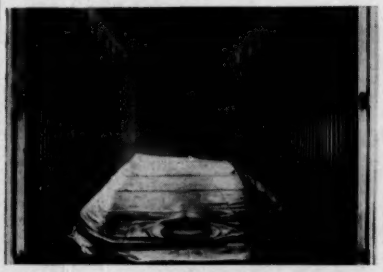
MORE

## *Polyethylene Liners in Collapsible Containers Used to Haul Bulk Liquids*

Disposable polyethylene liners are now being used within large collapsible containers to haul liquids which must be kept free of contamination in transit. Recently introduced for carrying edibles such as milk, fruit juices and vegetable oils, the lined containers have possibilities for many other raw materials as well.

These containers can be carried on any van or flat-bed trailer, including refrigerated vans, it is reported. They come in 22-, 30-, or 34-foot sizes, with capacities of 2,750, 4,000 and 4,600 gallons.

To free the vehicle for transporting dry freight following delivery, the disposable polyethylene liner is removed and the container is rolled into a compact package. For reuse, the container is unrolled on the floor of the vehicle and inflated. A new, sanitary polyethylene liner is then easily spread within the container and also inflated.



Collapsible container is unrolled on floor of trailer, inflated with low-pressure air.

Polyethylene liner is spread inside and inflated, and container is ready for loading.

CONTINUED

## *Ammonia*

nitrogen which reacts with steel to form a hard layer that resists wear at operating temperatures up to 750°F.

**Ammonia as Refrigerant**

Ammonia is one of the oldest and best refrigerants, and the most widely used in large installations. Advantages include low cost, low power consumption, low friction and vapor density, and high heat of vaporization.

**Ammonia for Water Purification**

In industrial and municipal water supplies, ammonia and chlorine in about a 1:4 ratio form mono and dichloramines which are delayed sterilizing agents. They permit higher residual chlorine concentrations without chlorine taste and odor.

Fertilizer applications account for over 75% of all ammonia produced, particularly in the Mid-West around U.S.I.'s ammonia plant at Tuscola, Ill. Consumption breakdown for other industries is:

| | |
|---|---|
| Chemical Processes | 7% |
| Explosives | 5% |
| Synthetic Fibers | 3% |
| Plastics & Resins | 3% |
| Pulp & Paper | 1.5% |
| Metallurgy | 1% |
| Miscellaneous | 3.5% |

CONTINUED

## *Aerosol Valve*

escape. In pressure-filling through this type of valve, the liquid propellent being injected must somehow get past the seal of the inlet port and into the container.

This problem has been solved in valve design by adding two ports to the bottom part of the valve stem. A special attachment on the standard pressure-filling head depresses the valve to its limit. The two added ports then bypass the inlet port seal and provide a passage through the valve stem into the container for injection of propellant.

## U.S.I. Names New V.P.

Paul J. LaMarche has recently been named Vice President of Production for U.S.I. Mr. LaMarche joined the company in 1949. Shortly thereafter, he became Manager of Sodium Sales. From 1951 to 1958, he was Manager of the company's plants at Ashtabula, Ohio. He became Director of Production in 1958.

Paul J. LaMarche

## *New Cold Soda Pulping Process in Pilot Stage*

Uniform penetration of hardwood chips to yield a uniform pulp with good fiber length is the major innovation claimed for a new, continuous system of cold soda pulping, now reported in pilot operation.

The process is reported to have the usual advantage of cold soda pulping over other methods—a combination of high yields (85-95%), low power needs (12-25 hp. per ton), low chemical requirements, low capital outlay. However, this new process has been designed to achieve uniform penetration of chips by caustic, a problem with other cold soda processes.

Chips are fed into a tapered-throat screw press having an extra length of piping (a plug pipe) at its outlet. The screw forces the chips into this plug pipe, compressing them and forcing the air out of them. Chips are discharged into the caustic soda reactor where they expand into a sponge-like mass which becomes completely impregnated with caustic.

Cold soda processing has grown very rapidly since 1956. It is estimated that about 300,000 tons of pulp were made by the various cold soda processes in 1960. Commercial use of this new continuous process could increase this figure rapidly.

## TECHNICAL DEVELOPMENTS

*Information about manufacturers of these items may be obtained by writing U.S.I.*

**Dehydrated firefly tails** now available for biochemical research. Can be processed into extract used to measure ATP (adenosine triphosphate). ATP, added to extract, produces light in proportion to quantity of ATP present.. **No. 1670**

**Pliable, easily cut refractory sheet for laboratory use** is now on market. Reported to be excellent insulator when hardened in air or 350°F even. Suggested for hand grips, pump jackets, insulation for vessels, small ovens. **No. 1671**

**New, highly-purified form of cellulose** for food, drugs, cosmetics, now obtainable in research quantities. Said to give very firm, stable, opaque, creamy gels that are smooth, odorless, tasteless, non-caloric. In dry, free-flowing form, said to absorb fats and oils. **No. 1672**

**New "Journal of Chemical Documentation"** to be published twice a year, starting in 1961. Designed to ease dissemination of chemical information. Will cover such topics as information services, machine processing of information, resources of nations on specific subjects. **No. 1673**

**Treating polyethylene film for printability** is covered in new booklet now available. Discusses physical treatments by flame and the more adaptable electronic methods. **No. 1674**

**High-purity isophthaloyl and terephthaloyl chlorides** now produced in semi-commercial quantities. Suggested as raw materials for new synthetic fibers; intermediates for pigments, drugs, adhesives, rubber. **No. 1675**

**Continuous addition of liquids to solids** in precise amounts is reportedly achieved by new process recently developed. Thorough mixtures are provided at rates from 500 pounds to 150 tons per hour, it is claimed. **No. 1676**

**New polycyclic alcohol** is said to supply perfumer with all desirable characteristics of natural sandalwood oil—in a single aromatic chemical. Reported to have better residual properties than sandalwood itself. **No. 1677**

**Use of radioactivity in developing and employing pharmaceutical agents** is subject of 180-page book now being sold. In series of papers, experts discuss uses in analysis, product development and evaluation, tracing of drugs. **No. 1678**

**Microporous cellulose acetate membrane** is offered as improved medium for electrophoresis. Advantages claimed: speed, sharp separation, reproducibility, sample economy, chemical inertness, membrane strength, broad scope. **No. 1679**

## *Technical Bookshelf*

### AIRING ON AETHER

A HISTORY OF THE THEORIES OF AETHER AND ELECTRICITY. Vol. I: The Classical Theories; Vol. II: The Modern Theories. By Sir Edmund Whittaker. Harper Torchbooks/The Science Library, New York. Vol. 1, 434 pp., $1.95; Vol. II, 319 pp., $1.85.

*Reviewed by Robert G. Morris, South Dakota School of Mines and Technology, Rapid City, S. D.*

First published in 1910, revised in 1951, and now in a softcover format, Vol. I contains a history of the theories of "Aether and Electricity" from the time of Aristotle to the start of the twentieth century, but essentially beginning with the Age of Descartes, Galileo and Kepler in about 1600. Vol. II, which first followed in 1953, carries the story on, with the origin and development of the quantum theory and relativity, up to 1926.

The title of the books must be taken in its broadest meaning for they are almost histories of all physical thought, so entwined are the theories of aether and electricity with all of physics, from optics and spectroscopy, Maxwell's equations, radioactivity and nuclear physics to matrix wave mechanics and gravitation.

Sir Edmund Whittaker (1873-1956), who retired from his chair in Edinburgh in 1946, is well-known for his mathematical treatises *Analytical Dynamics* and *A Course of Modern Analysis* (written with G. N. Watson).

As to the title of his present work, he justifies his use of the word *aether* (using the British spelling for the medium once commonly assumed to support transverse electromagnetic waves), rather than the more fashionable word *vacuum*, by pointing out that with the advent of quantum electrodynamics, this vacuum now is "the seat of the 'zero-point' oscillations of the electromagnetic field, of the 'zero-point' fluctuations of electric charge and current, and of a 'polarization.'"

He concludes: "It seems absurd

to retain the name 'vacuum' for an entity so rich in physical properties; and the historical word 'aether' may fitly be retained."

The book is not pedagogical, but presents the development of physical thought as actually conceived by the great and middling minds of physics. The development is presented with necessary mathematics, and goes to the heart of each question, stating the results, successes and failures. It is not a mere popular history of physics but a scientist's history for scientists; and, while few Ph.D's will appreciate all of it, any one with college physics will understand most of the mathematical presentation.

J. M. Ziman has written, of a branch of science, that "A unified picture can only be made by one person comprehending the whole scene." Sir Edmund Whittaker is one person who truly comprehended the whole scene and communicated it in a clear fashion.

**More New Books**

*Activation Analysis Handbook.* By R. C. Koch. Academic Press. $8.

*Infrared Methods—Principles and Applications.* By G. K. T. Conn and D. G. Avery. Academic Press. $6.80.

*Oxide Ceramics—Physical Chemistry and Technology.* By E. Ryshkewitch. Academic Press. $16.

*Quantitative Analysis.* By R.U. Brumblay. Barnes & Noble (College Outline Series). $1.50.

*The Structure of Glass. Vol. 2.* Various authors (translated from Russian). Consultants Bureau, New York. $25.

*Organometallic Chemistry* (ACS Monograph 147). Ed. by H. Zeiss. Reinhold. $17.50.

*Lectures on Theoretical Rheology.* By M. Reiner. Interscience. $4.85.

*An Outline of United States Patent Law.* By R. E. Brink, D. C. Gipple and H. Hughesdon. Interscience. $7.50.

*Symposium on Nondestructive Testing in the Missile Industry.* By various authors. American Soc. for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

*Cermets.* Ed. by J. R. Tinklepaugh and W. B. Crandall, Reinhold. $9.50.

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Photos of propane installation at Caterpillar Tractor Co., Aurora, Illinois. RegO-equipped by Fergeson Co., Cleveland, Ohio

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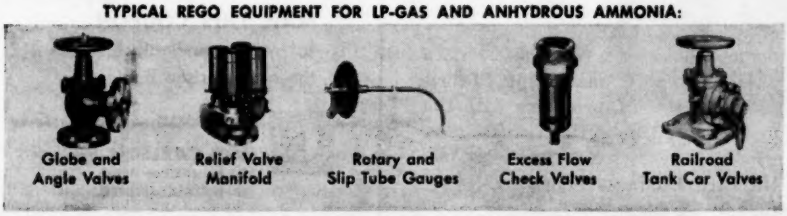


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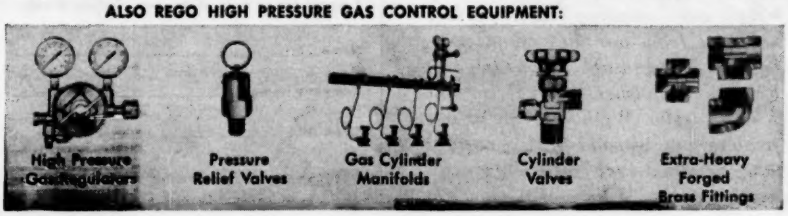



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- ☐ G-300 for High Pressure Gases

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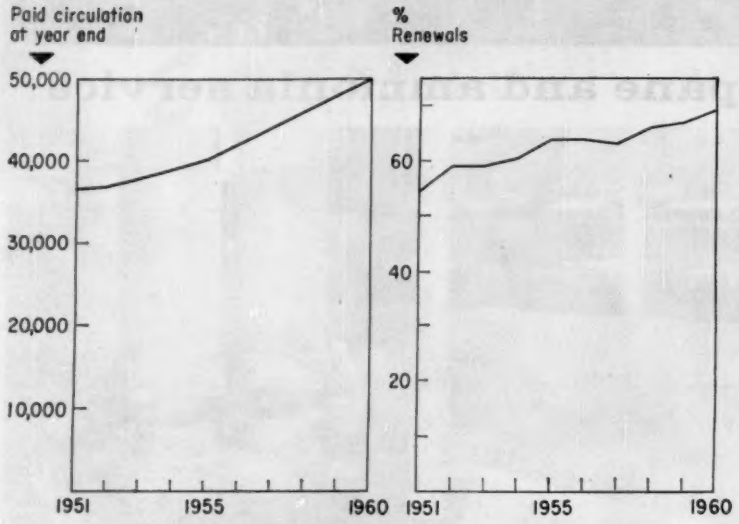
## *Letters: Pro & Con*

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*Dear Readers:*

If your subscription to *Chemical Engineering* began last month, you were among those who helped us reach our year-end goal of 50,000 subscribers.

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The fact that you pay to subscribe to *Chemical Engineering*—and can make or break us by turning thumbs up or down—is your guarantee that we will continually strive to merit your favor.

CECIL H. CHILTON
Editor-in-Chief
*Chemical Engineering*

### Wanted: Polycarbonate Data

*Sir:*

In partial fulfillment of the requirements of the Manufacturing course here at Harvard Business School, students form groups and write comprehensive topic reports. Our group has chosen polycarbonates as the subject of our report.

Because of the newness of this resin, we are having some difficulties in obtaining data about it. We would like to get any and all information available concerning polycarbonates. We need data about research marketing, fabricating, end uses, problems with the material and potential future uses.

DAVID E. MILLER
Harvard Business School
Boston 63, Mass.

▶*We are sending Mr. Miller material from our files on polycarbonates, including our exclusive Process Flowsheet story in our Nov. 14 issue. We hope some of our readers will respond to this request also, sending such information directly to Mr. Miller.*—ED.


## Tulip bed for stainless...

In our Viaduct Plant shear bay this "tulip bed for stainless" is important to you. It is this ball-bearing bed that helps our shearmen position plate easily, quickly, efficiently. But there's more than speed shown here. Carlson engineers modified this modern shear to provide unusually accurate cutting of stainless plate to your specifications.

Equipment of this type, coupled with our thorough knowledge of stainless steel, brings you the finest products . . . the finest service. For almost a quarter of a century it has been our aim to serve you best by producing what you want and delivering it on time.

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## *Manufacturers' Literature*

**Contents of This Issue**



### Chemicals

**Acetylene Chemicals**.....Data sheet describes in detail commercially available high-pressure acetylene derivatives. Chemical structures, physical forms and descriptions are given.
**192A** Antara Chemicals

**Activated Carbon**.....A complete line of activated carbons for every purpose. Complete purification, separation & recovery systems. Further details in Bul. J-104.
**R207** *Barneby-Cheney

**Alloys**.....Colmonoy Spraywelder is used to hard surface lathe-mounted pump parts. Provide double protection against harsh corrosion & abrasion. Catalog available.
**TL210** *Wall Colmonoy Corp.

**Ammonia**.....Anhydrous Ammonia is a versatile chemical employed in Agriculture & used by Industry in a wide range of operations from drug manufacture to explosives.
**185-186a** *U. S. Industrial Chemicals Co.

**Anti Static Agent**.....CATANAC SN prevents dust-gathering static charges on plastic, paper, glass and a wide variety of substances. Additional information is available.
**16-17c** *American Cyanamid Co.

**beta-Propiolactone** ..... Commercially available BPL is suggested as being potentially useful in paints, textiles, detergents, lubricants, adhesives & starches. Bul. N-61.
**83** *Celanese Chemicals Co.

**Caustic Soda**.....40-page booklet gives complete chemical and physical properties. Ten pages of graphs and tables are included and special sections are devoted to costs of caustic shipments.
**192B** U. S. Industrial Chemicals Co.

**Cellulose**.....For food, drugs, cosmetics, available in research quantities. Give firm, stable, opaque creamy gels that are smooth, odorless and tasteless. No. 1672.
**185-186d** U. S. Chemicals Co.

*From advertisement, this issue

**Citric Acid**.....30-page brochure lists the grade of citric acid available, its physical and chemical properties and their applications. Gives particle size specifications.
**193A** Miles Chemical Co.

**Cyanogum Gel**.....Specific data are available to permit comparison with Cyanogum's permeability with other well-known gels-viz agar, gellatin & silica.
**16-17a** *American Cyanamid Co.

**Defoamers**.....4-page brochure briefly describes how foam causes problems in processing industries and proceeds to describe defoamers designed to solve these problems.
**193B** E. F. Houghton & Co.

**Diethyl Carbonate**.....A new data sheet just released lists specifications, commercial information, typical reactions and uses of this chemical in detail.
**185-186b** *U. S. Industrial Chemicals Co.

**Fiberglass Reinforced Plastics**.....32-page illustrated booklet describes resins, reinforcements and releases used in laminating and casting, and includes data on contact and spray-up molding.
**193C** Allied Resins Products Corp.

**Filter Fabric**.....An illustrated booklet, "Filter Fabric Facts" helps solve problems concerning fiber, count & finish necessary to fabric's performance.
**62** *Wellington Sears Co.

**Fluorocarbon Resin**..... Details on properties & performance of Teflon in the new bulletin on "Lined Pipe" & general information in booklet "Designing with the Teflon".
**93** *E. I. du Pont de Nemours & Co.

**Industrial Filter Paper**.....A comparative chart of Industrial Filter Papers plus filter paper application guide for proper filtration of scores of products in Cat. 357.
**42** *The Eaton-Dikeman Co.

**Isophthaloyl & Terephthaloyl Chlorides**.....Now produced in semi-commercial quantities. Suggested as raw materials for synthetic fibers; for pigments, etc. No. 1675.
**185-186f** *U. S. Industrial Chemical Co.

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LITERATURE . . .

**Levulinic Acid**.....a particularly interesting chemical with polyfunctional characteristics. Acts both as a crboxylic acid & as a ketone. A new Bul. 301-A, is offered.
81 *The Quaker Oats Co., Chem. Div.

**Light Absorber**....Efficient on a variety of woods, CYASORB is added to retard wood discoloration from the effects of ultraviolet rays. Further details are available.
16-17d *American Cyanamid Co.

**Lithium Aluminum Hydride**.....Newly packaged in ether soluble packaging. Filled with pre-determined batch amounts. Reactions take an entirely new course. Brochure.
47 *Metal Hydrides Inc.

**Melamine**.....CYMELL1077 melamine impregnated decorative overlay becomes a permanent part of contour handles which are wearproof & washable. Details available.
16-17b *American Cyanamid Co.

**Membrane Filter**.....A microporous plastic with uniform micron sized holes, filter can be used to filter all radioactive particles from fluid and gas streams. Manual available.
194A Gelman Instrument Co.

**Microporous cellulose**.....acetate membrane is offered as improved medium for electrophoresis. Advantages include speed, sharp separation, reproductibility, etc.
185-186i *U. S. Industrial Chemicals Co.

**Mineral Oil**.....Bulletin describes use of white mineral oil as corrosion protectant on deep tanks that hold cotton seed, soya bean, coconut, etc.
194B Sonneborn Chemical & Refining Corp.

**Phthalic Anhydride**.....Tailores to particular commercial and technical requirements for first cost, feed stock, yield, product, purity, etc. Information on request.
63 *Foster Wheeler Corp.

**Plastic & Chemical Materials**.....1961 brochure describes complete line of polycarbonate resins, phenolic resins, varnishes and molding powders and fused magnesium oxide.
194C General Electric Co.

**Polybutenes**.....Oronite Polybutenes are non-drying, tacky and viscous. They offer excellent stability, outstanding electrical properties, etc. Tech. Bull. is available.
99 *Calif. Chem. Co., Oronite Div.

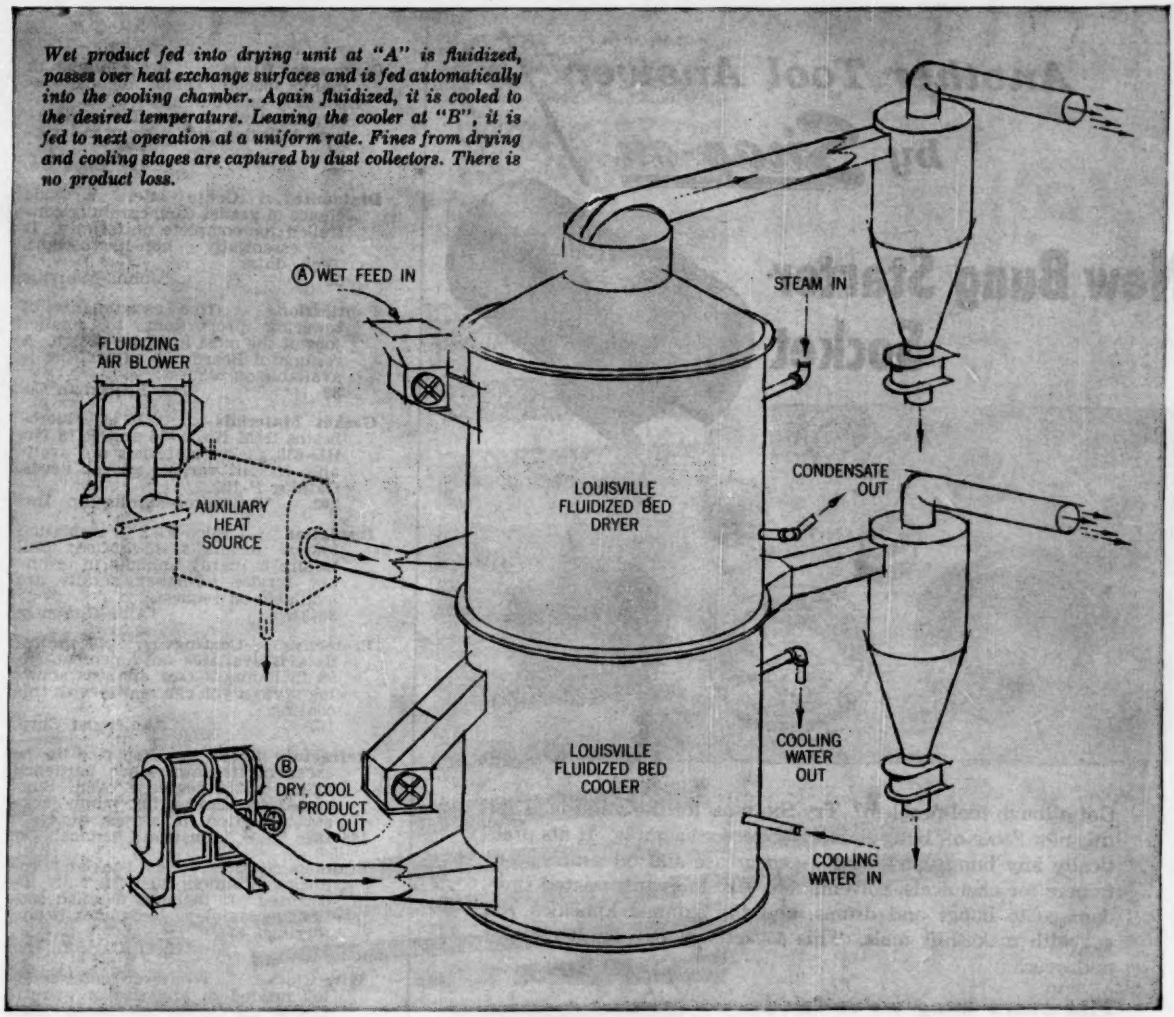
**Polycyclic Alcohol**.....Said to provide perfumer with all desirable characteristics of natural sandalwood oil In a single aromatic chemical. Has better residual properties.
185-186h *U. S. Industrial Chemicals Co.

**Silicone Defoamers**..... Job-proved thousands of times as the most efficient, most economical and most versatile foam suppressors available. Manual is offered.
R201 *Dow Corning Corp.

## Construction Materials

**Chemical Packing**.....Style 324 Super-Lon has all the known advantages of Teflon plus 50,000 psi tensile strength contrasted to 2,000 psi limitations in Teflon Resin.
182 *A. W. Chesterton Co.

*From advertisement, this issue




# Major break-through in drying and cooling techniques announced by

# GENERAL AMERICAN

A new system for drying and cooling has been perfected by General American Transportation Corporation through their development of Louisville Fluidized Bed* equipment. Two Louisville units, one functioning as a dryer and one as a cooler are coupled vertically to provide a continuous automatic operation.

The system is particularly useful for crystalline chemicals, resins, polyvinyl acetate beads, polyethylene pellets, sugar and similar products having the proper particle size distribution.

Louisville Fluidized Bed equipment offers these advantages:

1. Accurate, instantaneous temperature control
2. High heat transfer that permits compact design
3. Low maintenance costs (no moving parts)
4. Less cleaning time and labor
5. Less floor space (equipment is vertical)
6. No hot spots (product is fully protected)

Because of their simplicity, Louisville Fluidized Bed dryers and coolers adapt readily to complete automation.

*For full details about this revolutionary development in drying techniques, write Dept. F.*

Process Equipment Division

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**Compressor Rings**.....are available in many special Teflon blends, depending on your application. Information about new Teflon packings & Teflon piston rings in booklet.
56 *C. Lee Cook Co.

**Diatomite**.....Celite offers a wide choice of grades each carefully controlled for complete uniformity. It is essentially non-hygroscopic. Tech. data.
50 *Johns-Manville

**Fabrication**.....from assignments of towering proportions to smaller jobs of the most intricate design. A resume of Boardman capabilities is available on request.
89 *The Boardman Co.

**Gasket Materials**.....R/M Fluorobestos R/M No. A-56 and R/M No. RL-638 gasket materials are available to suit various gasket needs. Catalog P-100.
202 *Raybestos-Manhattan, Inc.

**Insulation**.....Silco-Flex insulation system means fast service. Coil failure is highly unlikely in ordinary service. Further details are available on request.
30-31c *Allis-Chalmers

**Protective Coatings**..... Technical data is available on Amercoat No. 99 including a cost analysis showing savings you can realize with this coating.
167 *Amercoat Corp.

**Refractory Sheet**.....Reported to be excellent insulator when hardened in air or 350 degree F oven. Suggested for hand grips, pump jackets, insulation for vessels, etc.
185-186c *U. S. Industrial Chemicals Co.

**Stainless Steel**.....New booklet "Producing Stainless Steel" is fully illustrated. It includes detailed sections on stainless steel plates, heads, forgings, etc.
190 *G. O. Carlson, Inc.

**Wire Cloth**.....Whatever metal or alloy needed in any size or quantities to the closest tolerances. High mesh counts are featured. An illustrated 120 pg. catalog.
108 *The Cambridge Wire Cloth Co.

## Electrical & Mechanical

**Autotransformer**.....Starter for squirrel cage motors that should not be started at full voltage. Reduces line voltage during acceleration. Bulletin 746
61a *Allen-Bradley Co.

**Autotransformer Starter**.....Operated manually where load conditions or power company rules require reduced voltage starting. Further details in Bul. 646.
61d *Allen-Bradley Co.

**Convertible Vaportight Fixtures**..... The V-51 series require only seconds to relamp or convert. Available in a variety of hub sizes in pendent, ceiling, or bracket type.
1 *Appleton Electric Co.

**Explosion-Proof Electrical Devices**..... Catalog lists nearly everything you would want for hazardous areas. Both conventional and out of the ordinary devices are offered.
70 *Crouse-Hinds

*From advertisement, this issue

LITERATURE . . .

**Joints**.....Bellows-Flex Joints of Fluoroflex-T are molded rather than machined. Adjusts to longitudinal and temperature movements. Information.
8-9b *Resistoflex Corp.

**Mechanical Seal**.....Dura Seal will meet your sealing needs. Low in original cost with the least maintenance cost. Further details are offered in Catalog 480-CE.
L206 *Durametallic Corp.

**Mechanical Seals**.....Chemiseal mechanical seals are available in standard sizes to fit all pump shafts ⅞" to 2⅛" shaft. Details in Catalog AD-164.
54 *Garlock, Inc.

**Motor Control Centers**.....Bulletin SM-244 gives detailed information on all of the "plus" advantages you get when you specify these motor control centers.
29 *Square D Co.

**Part Winding Starter**.....Used on squirrel cage motors having 2 separate parallel windings. Made in two step & three step types. Further details in Bulletin 736.
61g *Allen-Bradley Co.

**Rectifiers**.....as well as complete semi-conductor power conversion equipment and systems for any AC to DC application. "Guide" to Industrial Rectifier Equipment.
91 *The Meaker Co.

**Resistance Starter**.....Graphite resistors automatically inserted in series. Can easily be adjusted to motor and loading conditions for smooth acceleration. Bul. 740.
61c *Allen-Bradley Co.

**Resistance Starter**.....Multipoint resistance starter used on network systems. Time intervals can be adjusted to provide velvet smooth starting. Bul. 741.
61e *Allen-Bradley Co.

**Stepless Resistance Starter**.....Has graphite compression disc resistors for smooth starting. Under complete control of the operator. Bulletin 640.
61b *Allen-Bradley Co.

**Stepless Resistance Starter**.....Completely automatic. It will satisfy any power company requirement. Eliminates lamp flicker on networks used for lighting. Bul. 742.
61f *Allen-Bradley Co.

## Handling & Packaging

**Exhausters**.....Clarage Type CI Exhausters have volumes to 3800 CFM, pressures to 18", temperatures to 750°F., six sizes, three wheel types and five arrangements. Catalog 707.
44 *Clarage Fan Co.

**Pneumatic Conveying Systems**.....New bulletin M-260 discusses types of systems, illustrates & diagrams high and low density arrangements. Shows equipment & gives details.
176a *The Day Co

**Rotor Lift**.....Moves up to 6,000 cu. ft. per hr. quietly. Eight basic types, 4 diameters in stainless steel, aluminum, galvanized or black iron. Catalog is available.
L200 *Southwestern Supply & Machine Works

*From advertisement, this issue

LITERATURE . . .

**Screw Feeders**.....8-page folder indicates density in pounds per cubic foot for each of 456 materials tested, screw size of the feeder and maximum rate in pounds per min.
**199A** Vibra Screw Feeders, Inc.

**Storage Tanks**.....Twelve page bulletin describes horizontal & vertical storage tanks. Points out savings & is filled with photos of various installations. Bul. 574.
**176b** *The Day Co.

**Storage Tanks**.....Twelve page bulletin describes horizontal & vertical storage tanks. Points out savings & is filled with photos of various installations. Bul. 574.
**176b** *The Day Co.

**Transportation Equipment**.....Every unit is engineered to meet service requirements, including complete piping, metering and transfer equipment. Details.
**4** *Pressed Steel Tank Co.

## Heating & Cooling

**Autoclaves**.....A 16-page illustrated catalog on industrial heating applications is offered. Engineering service is also available. Send for illustrated catalog.
**R206** *Posey Iron Works, Inc.

**Drum Heater**.....Accurately controlled temperatures to 550 degrees F. can be obtained. Rugged casters for easy moving. This heater weighs only 95 lbs. Bul. DH-100
**64** *Glas-Col Apparatus Co.

**Drying & Cooling System**.....Louisville fluidized bed equipment offers many advantages. Accurate, instantaneous temp. control, high heat transfer and others. Details.
**195** *General American Transp. Corp.

**Extruders**.....Thermatic Series extruders have capacity to permit high heat application, ample cooling along the barrel and higher head pressure. Facts are available.
**187** *Davis-Standard

**Fired Heaters**.....Heaters designed for high thermal efficiency allowing the use of a wide range of fuels. Special systems constructed for unusual requirements. Details.
**57** *Struthers Wells Corp.

**Gas Absorber**.....“Buffalo” gas absorbers are designed to render many nuisance or destructive effluents harmless. Handle a wide variety of problems. Bul. AP-225.
**6-7a** *Buffalo Forge Co.

**Gradiation Heating**.....offers zone control, uniformity of heating, etc. Bulletin “Gradiation Heating for Petroleum and Chemical Processing” is available.
**66** *Selas Corp. of America

**Grate-Kiln System**.....produces consistent high quality using less fuel. Outproduce conventional rotary kilns of the same length by 50%. Further information is available.
**30-31b** *Allis-Chalmers

**Heat Recovery Systems**.....Bulletin TKB-3 describes these unexcelled heat recovery systems and the many outstanding features that they offered.
**26b** *Traylor Engineering & Mfg.

*From advertisement, this issue

## LITERATURE . . .

**Heat Transfer**.....Exclusive Multi-Zone design offers optimum steam distribution. Serpentine styles are also available for cooling. A bulletin No. P61 is available.
**58** *Tranter Mfg. Co., Platecoil Div.

**Immersion Heater**.....Can heat to any desirable temperature above those possible with steam. A complete line of steam & direct fired coils described in Buls. 300 & 410.
**111** *Brown Fintube Co.

**Panelcoil**.....Complete engineering and pricing data are available in new Technical Data Sheets Nos. 15-60 series and Price Bulletin 259 which may be had on request.
**TL207** *Dean Products, Inc.

**Plate Heat Exchanger**.....features stainless steel construction which solves almost all corrosion problems or assures sanitary operations. Cleaning is unusually easy.
**24-25a** *The De Laval Separator Co.

**Rotary Kilns**.....feature full-floating type roller ring and roller supports which insure easy alignment & continuous operation. Bulletin No. 1115.
**26a** *Traylor Engineering & Mfg.

**Steam Trap**.....The No. 130 is designed specifically for thousands of light condensate load applications such as steam main drips, meter boxes, etc.
**38** *Yarnall-Waring Co.

**Steam Traps**.....Type TD-50 can be used to control moisture content automatically. Other advantages include simplified piping, saved space, easy maintenance. Details.
**60** *Sarco Company, Inc.

**Vapor Condenser**.....The Aero Vapor Condensers are manufactured in standard units in a range of capacities up to thirty million Btu's. Bulletin 129-R.
**B218** *Niagara Blower Co.

**Vortex Tube**.....is the answer to small scale refrigeration or cooling requirements. Bulletin K-8 contains information on Hilsch Vortex Tube for hot & cold air.
**BL210** *Fisher Governor Company

## Instruments & Controls

**Annunciators**.....De-Line annunciators with Magna-Plac require less panel space than most with conventional nameplates. Heavy, molded, white translucent acrylic.
**200A** *Scam Instrument Corp.

**Chromatograph, Gas**.....features tape-programmed control unit. The new tell-all bulletin on this new chromatograph is now available on request.
**43** *Mine Safety Appliances Co.

**Control Center**.....New SpaceMaker control center is the first completely new 2- to 5-kv. motor controller in more than a decade. Further details are available.
**30-31d** *Allis-Chalmers

**Controller**.....The new Frac Controller adjusts column operation to the effects of ambient temp. on overhead product condenser & external reflux. Details.
**14-15** *Minneapolis-Honeywell

*From advertisement, this issue

## LITERATURE . . .

**Controls, Liquid Level**.....Magnetrols have no wearing or flexing members. Eliminate the ultimate causes for failure of ordinary controls. Information is available.
**200B** *Magnetrol Inc.

**Flow Meters**.....Options and general information, performance data design specifications and ordering information are among the things discussed in Bul. 56-B-3.
**201A** *Industrial Instrument Corp.

**Industrial Thermometer**.....New "Adjus-All" thermometer adjusts to desired position, adjusts the hinge assembly to any angle and adjusts stem length.
**201B** *Weksler Instruments Corp.

**Level Control**.....Electr-O-Probes are available in three models; B-04 super-sensitive relay, B-05 general purpose relay, and B-06 self-contained. Bulletins.
**T218** *Instruments, Inc.

**Meter**.....Both Models N-1 and N-2 are supplied with a complete complement of basic electrodes & other essential equipment. Tech. details in Data File 14-4-01.
**39** *Beckman Instruments, Inc.

**Process Controls**.....PoweMag controls produces all control actions-proportional band, reset, rate-multiplication, addition, subtraction. Information.
**103** *Hagan Chemicals & Control.

**Recording Gages**.....Bulletin 84 P-1 describes PR-12 Series, Pr-8 Series and contains a list of ordering specifications along with recording gage accessories.
**201c** *Industrial Instrument Corp.

**Temperature Controller**.....Thermotrol is a general purpose laboratory temperature controller. It is designed to operate using any one of three control methods.
**201D** *Hallikainen Instruments

## Pipe, Fittings & Valves

**Condenser Tube Protectors**.....Fluoroflex-T condenser tube protectors eliminate erosion and corrosion by high-velocity acid on entry side of condenser tubes. Information.
**8-9d** *Resistoflex Corp.

**Hose, Transfer**.....Fluoroflex-T transfer hose is completely corrosion-resistant with long flex life. Available in cover of rubber or stainless steel braid. Details.
**8-9c** *Resistoflex Corp.

**Pipe, Epoxy**.....A complete size range that handles a temperature range from 65 to 300 F. Withstands an operating pressure range up to 1,200 psi. Information.
**45** *Fibercast Co.

**Pipe, Steel Lined**.....Fluoroflex-TS is prefabricated to length with flanges —ready to assemble. It minimizes assembly time and shortens checkout time. Inform.
**8-9a** *Resistoflex Corp.

**Pipe Fittings**.....Speedlines controlled wall thickness can make a difference in your critical process lines. Complete catalog information available on request.
**101** *Horace T. Potts Co.

* From advertisement, this issue

LITERATURE . . .

**Safety Relief Valves**.....“O” Ring Seat Seal prevents leakage in the most difficult applications and saves on maintenance costs. Bulletin 1040 is available.
**202A** *Manning, Maxwell & Moore, Inc.

**Spray Nozzles**.....Fulljet nozzles for multiple nozzle applications. The latest design in spraying systems in square & circular spray patterns. Bul. 105 & Cat. 24.
**TL209** *Spraying Systems Co.

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| 4 | 20 | 33-34c | 44 | 61a | 77 | 98C | 108 | 176a | 179 | 185-186e | 193A | R200 | 206B | 210B | | | | | | |
| 6-7a | 21 | 33-34d | 45 | 61b | 81 | 98D | 111 | 176b | 180 | 185-186f | 193B | 200A | 206C | 210C | | | | | | |
| 6-7b | 22-23 | 33-34e | 46a | 61c | 83 | 98E | 116 | 176A | 180A | 185-186g | 193C | 200B | TL207 | 210D | | | | | | |
| 6-7c | 24-25a | 33-34f | 46b | 61d | 85 | 98F | 117 | 177 | 180B | 185-186h | 194 | L201 | BL207 | 210E | | | | | | |
| 6-7d | 24-25b | 33-34g | 47 | 61e | 87 | 98G | 118 | 177A | 180C | 185-186i | 194A | R201 | R207 | 210F | | | | | | |
| 8-9a | 24-25c | 35 | 48 | 61f | 89 | 99 | 119 | 178a | 180D | 187 | 194B | 201A | 207A | T218 | | | | | | |
| 8-9b | 26a | 36-37 | 49 | 61g | 91 | 100A | 120 | 178b | 181 | 188 | 194C | 201B | 207B | B218 | | | | | | |
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| 8-9d | 27 | 39 | 51-52 | 63 | 94A | 102A | 163 | 178d | 182A | 189b | 196 | 201D | 208A | B219 | | | | | | |
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| 16-17a | 30-31b | 41c | 56 | 67 | 96A | 104A | 171 | 178h | 185-186a | 192A | L199 | L206 | R209 | 222 | | | | | | |
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| 76 | 78 | 79 | 80 | 81 | 82 | 83 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 |
| 100 | 101 | 102 | 103 | 105 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 |
| 125 | 126 | 127 | 128 | 129 | 130 | 131 | 133 | 135 | 136 | 138 | 139 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 |
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| 125 | 126 | 127 | 128 | 129 | 130 | 131 | 133 | 135 | 136 | 138 | 139 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 |
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33-34g—Chemical Dispensing Valves
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**Air Pollution**—CPI plant solutions (50¢).....143
**Control Valves**—Behavior and selection (75¢).....141
**Estimating Engineering Properties**
Thermal Conductivity (50¢) ..... 94
Heat Capacities (75¢). 109
Latent Heat (75¢)....117
Surface Tension (75¢). 126
Viscosity (75¢) ..... 138
Critical Properties (75¢). 149
Other Physical Properties (50¢) .....151
**Flowsheets**—Engineering communiques (50¢)..... 99
**Flow File**—50 design formulas (50¢).....112
**Flow Through Packing and Beds**
Packed Towers (50¢).....103
Fixed and Moving Beds (50¢).....107
Fluidized Systems (50¢).....108
**Heat Exchanger Design**—Shortcut methods (75¢)..... 52
**Heat Exchanger Calculations**—Use these charts ($1).....136
**Instruments**—"Hardware" section of Report 95 (50¢).... 96
**Mechanical Seals**—How to select and use (50¢)..... 83
**Piping**—Roundup of process pipe, valves, fittings (75¢)... 40
**Process Design: Fluid Flow**—Size lines, pick pumps ($1)..161
**Process Control**—Instrumentation report ($1)..... 95
**Pump Seals**—Chemical plant practice (50¢)..... 92
**Water Conservation**—Will taps run dry? (50¢).....105
**Water Pollution**—Solve plant problems (50¢).....122
**Your Design Reference File**
Parts I-V (75¢).....100
Parts VI-IX (75¢).....110

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**Biochemicals Processing**—The total picture (50¢)..... 93
**Bio-oxidation**—Treatment of wastes (50¢)..... 68
**Chemicals from Petroleum**—Available processes ($1)....139
**Extractive Metallurgy**—By chemical processing (50¢)....111
**Ultra-Low Temperatures**—Production and uses (50¢).....133
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**Plants & Facilities**—Tenth Inventory 1959 (75¢).....158
**Processes & Technology**—Eighth Inventory 1958 (50¢)...118
**Processes & Technology**—Ninth Inventory 1959 (50¢)....159

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**Buyer-Seller Relations**—Vendor's view (50¢).....157
**Capital Cost Estimating**—Data, sources & methods ($1)...156
**CE Cost File**—Quick estimating data (50¢).....153
**Cost Control Systems**—Reduce and control costs (50¢)....102
**Inflation**—How to predict a shrinking dollar (50¢)..... 78
**Modernization**—Tighten up for profits (75¢).....128
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**Petrochemicals**—1958 economic review (50¢).....123
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**Professional Registration**—For PE-Minded ChE's (50¢)... 85
**Rockets and Missiles**—Airborne reactor problems (75¢)...119
**60's Challenge Chemical Engineers** (50¢).....152

### • Unit Operations

**Absorption With Chemical Reaction**—(50¢).....162
**Adsorption**—Design, methods, materials (50¢).....154
**Azeotropic Separation**—Close-boiler distillation (50¢)....160
**Binary Distillation**—Theory, equipment (75¢)..... 54
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**Crystallization**—For purification (50¢).....124
**Drying**—Methods, equipment, design, costs (75¢)..... 70
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**Ion Exchange**—Process, design and applications (75¢).... 55
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**Solids Concentration**—Survey of techniques (50¢)..... 67
**Solids-Gas Contacting**—Commercial practice (50¢)..... 63
**Solids-Liquid Separation**—Unit operations description ($1). 62
**Solid-Solid Blending**—Theory, practice, equipment (75¢).163

### • Chemical Engineering Science

**Analog & Digital Computers**—In engineering use (50¢)...145
**Speculative Process Design**—Pilot plant bypass (50¢)....146
**Pilot Plant**—All the aspects of scale up ($1).....127
**Statistics**—How to use data effectively (75¢)..... 73
**CE Refresher**
Thermodynamic Principles (50¢)..... 42
Compression & Expansion (50¢)..... 45
Chemical Equilibrium (50¢)..... 49
Homogeneous Kinetics (50¢)..... 57
Catalytic Kinetics (50¢)..... 61
Interpreting Kinetics (50¢)..... 66
Simple Reactor Design (50¢)..... 72
Complex Reactor Design (50¢)..... 75
Catalytic Reactor Design (50¢)..... 81
Reactor Design Problems (50¢)..... 87
Physical Equilibrium I (50¢)..... 90
Physical Equilibrium II (50¢)..... 97
Fluid Flow Equations (50¢).....101
Fundamental Math (75¢).....113
Mass Transfer Operations ($1).....130
Unit Operations Refresher
Fluid Flow (50¢).....144
Sedimentation Theory (50¢).....148
Heat Transfer (50¢).....155
Unsteady State Heat Transfer (50¢).....164

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**Absorption Methods**—Unit operation refresher (50¢)...168
**CPI Forecast for '61** (50¢).....170
**Conference on the New Chemical Engineering** ($1.50)..173
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**Plants & Facilities**—Eleventh Inventory 1960 (50¢)...167
**Processes & Technology**—Tenth Inventory 1960 (50¢)..171

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46b *The Sharples Corp.

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206B Oxy-Catalyst, Inc.

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107 *Great Lakes Carbon Corp.

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R198 *C. I. Hayes, Inc.

**Hydrator**.....The Super-D-Hydrator offers capacities from a few hundred lb./hr. to 25 tons/hr., depending on characteristics of slurry. Bulletin 1286.
46a *The Sharples Corp.

**Molecu-Dryer**.....is complete, compact and self-contained. Offers simplified design, low initial cost and continuous operation. Details contained in Bul. 5703A.
206C *C. I. Hayes, Inc.

**Mills, IMP**.....This rugged IMP mill is a multi-purpose grinding unit. Designed for grinding, blending, separating, conveying and drying. Catalog #87E.
118 *Combustion Engineering, Inc.

**Mixer**.....Nauta Mixer offers new three-way action. It features highest mixing accuracy, lowest mixing time, easy addition of liquids, starts under full load, etc. Bulletin.
180 *The J. H. Day Co.

**Mixers**.....Lightnin mixers cut downtime in three places at once. They offer shaft seal assemblies and come all assembled in one package, aligned & ready to install.
222 *Mixing Equipment Co., Inc.

**Mixers**.....Process-rated for optimum performance. A full line of mixers is available—side drive, tank top, portable or tripod, etc. Further details in Bulletin 581.
20 *Nettco

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184 *Philadelphia Gear Corp.

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24-25b *The De Laval Separator Co.

**Pulverizers**.....Mikro-Pulverizer offers fine or ultra-fine grinding, precise particle size control & economy of power and maintenance. Bulletin 51A is available.
163 *Mikro-Products Pulv. Mach. Co.

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T220 *The V. D. Anderson Co.

**Rotary Airlock Feeders**.....Complete information on these feeders for dust control and pneumatic conveying is contained in Bulletin P 58.
BL209 *Prater Pulverizer Co.

**Screen Separator**.....The Syncro-Matic offers single, double or triple decks of plain or composite screens in a full range of commercial meshes & materials. Data.
24-25c *The De Laval Separator Co.

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207A Cooper-Bessemer Corp.

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12-13 *De Laval Steam Turbine Co.

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27 *Joy Mfg. Co.

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207B Sutorbilt Corp.

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**Centrifugal Pumps**.....12-page selection catalog includes charts showing recommended temperature and pressure ranges for 10 classifications of pumps. Specifications.
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**T219** *Sulzer Bros, Inc.

**Pump**.....New Series G Chempump all but does away with bearing maintenance. Features have been field-proved in over 100 installations. Bulletin 2050.
**68** *Chempump Div. Fostoria Corp.

**Pumps**.....Electric-Cand pumps are built without packing, stuffing box or seals—the unit is completely fluid tight. Safely handles a wide variety of fluids. Details.
**30-31a** *Allis-Chalmers

**Pumps**.....Parts are standardized and readily interchangeable. Plant expansion is economical because of their adaptability. Complete descriptive lit. available.
**21** *The Deming Co.

**Pumps**.....A complete line of pulsafeeder pumps with metered flow rates from a few drops to 15.7 gal. per minute; pressures up to 7,000 psig. New Catalog 59.
**49** *Lapp Insulator Co.

**Pumps**.....Type CWO-C vertical shaft centrifugal pump is available in sizes from 1" to 16" capacities. It is easy to maintain. Details are given in Nagle Pump Selector.
**B220** *Nagle Pumps, Inc.

**Pumps**.....Three new "small pump" models to choose from. Offer many special advantages to cover many more "small pump" applications. Information is available.
**Cover** *Worthington Corp.

**Pumps, Acid**.....are available with pumping parts of machinable alloys as well as plastic to meet every need in the handling of corrosives, hot liquids, etc. Details.
**221** *A. R. Wilfley & Sons, Inc.

**Pumps, Centrifugal**.....New catalog 130 describes 50 different models. Offer pressures : to 21 psi. in single stage pumps; to 70 psi. in multistage types.
**55** *Eastern Industries Inc.

**Pumps, Single Suction**.....Available in cast iron or practically every alloy for a wide variety of chemical liquids. Interchangeable parts for economical maintenance.
**6-7d** *Buffalo Forge Co.

**Volume Pumps**.....32-page bulletin on controlled volume pumps features selection data guide, materials selection charts and capacity-pressure selection tables.
**208B** Milton Roy Co.

* From advertisement, this issue

LITERATURE . . .

## Services & Miscellaneous

**Cleaning Service**.....Process equipment can be cleaned with dismantling without scraping, rodding or sandblasting. No lengthy breaks in production. Tech. Bulletin.
192 *Oakite Products, Inc.

**Conversion Table**.....Wallet sized table of conversion factors deals with weight-volume, gravity or light and heavy liquids, base weight, power, temperature, pressure, flow, etc.
210A The Ohmart Corp.

**Data Analysis & Recording System**.... features expandable into a larger system at minimum cost, modular construction and self-checking circuits. Catalog EDP 150.
210B *Radio Corp. of America

**Drum Branding**.....Available on request is a Drum Branding Brochure to help you with your drum branding problems. Gives latest information to prevent slow downs.
B219 *Diagraph-Bradley Industries, Inc.

**Film Catalog**.....Guide to technical films for use by business, industry and commercial and engineering colleges lists over 130 films.
210C Modern-Talking Picture Service, Inc.

**Fire Fighting Products**.....Double strength foam is inexpensive & completely effective. Puts out fires fast, reduces storage costs & shipping costs. Information.
35 *Rockwood Sprinkler Co.

**New Process**.....Continuous addition of liquids to solids in precise amounts is achieved by new proces recently developed. Mixtures at rates of 500 lb. to 150 tons per hr.
185-186g *U. S. Industrial Chemicals Co.

**Pneumatic Receiver**. . ..Series 670 receiver incorporates features not previously available to make it easy to install, easy to use, easy to maintain. Bul. A124.
210D *The Bristol Co.

**Polyethylene film**.....Treating of this film for printability is covered in a new booklet now available. Discusses treatment by flame & more adaptable electronic methods.
185-186e *U. S. Industrial Chemicals Co.

**Safety Material Catalog**.....24-page catalog lists most recent material for use in non-occupational safety programs. Traffic, home and recreational programs are covered.
210E National Safety Council

**Starter Socket**.....Fits around the outside circumference of small bungs, the inside circumference of large bungs, enabling the housing to engage various bungs. Details.
196 *Snap-On Tools

**Storage Units**.....Designed and fabricated to exactly meet your requirements. Welding know-how with aluminum, stainless and alloys for low temp. duty. Information.
97 *Pittsburgh-Des Moines Steel Co.

**Temperature Conversion**....Chart permits rapid, accurate conversion from any scale—Kelvin, Rankin, Centigrade or Fahrenheit—to any other scale. Range zero to 16,000C.
210F Rosemont Engineering Co.

*From advertisement, this issue

# PROFESSIONAL SERVICES

**ARIES ASSOCIATES, INC.**
*Consultants to the Chemical Industries*
New Products and Processes
New Products Development
Design & Initial Operation of Complete Plants
Process Analysis—Market Research
COMPLETE TECHNICAL & ECONOMIC SERVICES
225 Greenwich Ave. DA. 5-2236 Stamford, Conn.

**CARL DEMRICK**
*Technical Translations*
Send for Circular
53 So. Broadway Yonkers, N. Y.

**Consult these SPECIALISTS**
Let them save your time by bringing their broad experience in their specialty to bear on your problems.

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**About Classified Advertising**
*Contact The McGraw-Hill Office Nearest You*

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Copley Square *COngress 2-1160*
M. J. HOSMER

CHICAGO, 11
520 No. Michigan Ave. *MOhawk 4-5800*
W. J. HIGGENS

CLEVELAND, 13
1164 Illuminating Bldg. *SUperior 1-7000*
W. B. SULLIVAN

DALLAS, 2
1712 Commerce St., Vaughn Bldg. *RIverside 7-5117*
J. GRANT

DENVER, 2
1700 Broadway—Tower Bldg. *ALpine 5-2981*
J. PATTEN

DETROIT, 26
856 Penobscot Bldg. *WOodward 2-1793*
P. HAMMOND

HOUSTON, 25
Prudential Bldg., Holcombe Blvd., Rm. W-724 *JAckson 6-1281*
GENE HOLLAND

LOS ANGELES, 17
1125 W. 6th St. *HUntley 2-5450*
W. C. GRIES

NEW YORK, 36
500 Fifth Ave. *OXford 5-5959*
H. T. BUCHANAN—R. P. LAWLESS
T. W. BENDER

PHILADELPHIA, 3
Six Penn Center Plaza *LOcust 8-4330*
H. W. BOZARTH—P. PASCHALL

PITTSBURGH, 22
4 Gateway Center *EXpress 1-1314*
P. PIERCE

ST. LOUIS, 8
3615 Olive St. *JEfferson 5-4867*

SAN FRANCISCO, 11
255 California St. *DOuglas 2-4600*
D. GARDNER

# *Employment Opportunities*

**CE's nation-wide coverage brings you tips and information on current opportunities in job functions throughout the chemical process industries.**

▶ **Displayed Rates**—$54 per inch for all ads except on a contract basis; contract rates on request. An advertising inch is measured ⅞ in. vertically on a column; 3 columns, 30 in. per page. Subject to the usual agency commission.

▶ **Undisplayed Rates**—$2.10 per line, 3 lines minimum. To figure advance payment count 5 average words as a line; box number counts as 1 line. 10% discount if full payment is made in advance for 4 consecutive insertions. Not subject to agency commission.

*SECTION HEAD*
**METALLURGICAL ENGINEER**
**Salary $16,000 Per Year**
Field of materials and coatings for radiation type heat shields for re-entry vehicle design and problems associated with orbital vehicles. Company client assumes all employment expense.
**ESQUIRE PERSONNEL INC.**
202 S. State St., Chicago 4, Ill.

*POSITION VACANT*

**Large Florida West Coast Chemical Plant** expansion requires chemists and chemical engineers for process and quality control and applied research and development of new and existing processes. B.S. degree in chemistry or chemical engineering required and one to five years experience preferred. Send resume to Personnel Director, P.O. Box 3269, Tampa 2, Florida.

*SELLING OPPORTUNITY WANTED*

**W Pa-W Va Mfg Rep seeks addtl estblshd** line cpbl. sccsfl. knows chem. ind.—replies conf. Pitts. Eng. Sales Co. Pitts. 16, Pa.

*Put Yourself in the Other Fellow's Place*

## TO EMPLOYERS - TO EMPLOYEES

Letters written offering Employment or applying for same are written with the hope of satisfying a current need. An answer, regardless of whether it is favorable or not, is usually expected.

**Mr. Employer,** won't you remove the mystery about the status of an employee's application by acknowledging all applicants and not just the promising candidates.

**Mr. Employee** you, too, can help by acknowledging applications and job offers. This would encourage more companies to answer position wanted ads in this section.

We make this suggestion in a spirit of helpful cooperation between employers and employees.

This section will be the more useful to all as a result of this consideration.

*Classified Advertising Division*

**McGRAW-HILL PUBLISHING CO., INC.**
330 West 42nd St., New York 36, N. Y.

## Editorial Position

**Immediate opening on Chemical Engineering's editorial staff of 19 engineer-editors for another young engineer to solicit, evaluate, edit or write technical news stories or articles on process and engineering developments and trends in the chemical process industries. Unusual opportunity to broaden industry and professional contacts, education and experience. Requirements: Degree in chemical engineering or closely related field with 1-5 years experience in chemical process work; ability to evaluate chemical process and engineering information; able to write clearly, concisely and accurately; must like and work well with people; initiative and imagination. New York City location with opportunity for some out-of-town travel. Please send complete resume of education, experience, salary requirement and other pertinent information to:**

**Personnel Dept.**
**McGraw-Hill Publishing Co.**
**330 West 42nd Street**
**New York 36, New York**

## PROCESS ENGINEERS

**McKee of Cleveland, Ohio offers permanent career opportunities with a rapidly expanding professional organization. Individuals possessing a minimum of 10 years experience in the design of petroleum, petro-chemical or general chemical producing facilities will be afforded unlimited advancement opportunities.**

***Reply in confidence to:***

**G. VICTOR HOPKINS**
**ARTHUR G. McKEE & COMPANY**
**2300 Chester Ave. Cleveland 1, Ohio**

## ASSISTANT PLANT ENGINEER

**Leading multi-plant, producer of fertilizers, needs Assistant Plant Engineer for integrated sulfuric, phosphoric and fertilizer plant in Gulf Coast area. Requirements: B.S.M.E. degree or equivalent, and a minimum of two years direct maintenance experience in administering maintenance program, plant modifications and new construction in plants of this type.**

**Excellent starting salary and Company benefits with opportunity for advancement. Resumes submitted will be given prompt attention and will be maintained in confidence.**

**P-5842,** Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

## *Equipment Searchlight*

**CE's Searchlight spots the big bargains in used, resale and rented equipment. Check this issue's listings—most complete in the field—for items you need now.**

▶ **Coverage** — National. Equipment and facilities—used, resale and rental—for the process industries. For sale, wanted, for rent.

▶ **Rates**—$21.75 per inch for all ads except on a contract basis; contract rates on request. An advertising inch is measured ⅞ in. vertically on a column; 3 columns, 30 in. per page. Ads acceptable only in display style.

▶ **Closing date** — February 20th issue closes January 27th. Send all new ads to Chemical Engineering, Classified Adv. Division, P. O. Box 12, New York 36, N. Y.

## CHEMICAL EQUIPMENT DIVISION

*Proudly Presents*

## *Another* CHEMICAL PLANT

# LIQUIDATION

**at NIAGARA FALLS, N. Y.**

**Pfaudler 500 gal. Type ELL Glass Lined, jktd., agit. Reactor**
**Dopp 1000 & 1700 gal. Ni-Resist Doployy, jktd., agit. Reactors**
**Goslin Birmingham 36"x24" Stainless Rotary Vacuum Filter**
**Buflovak 6"x8" double drum Rotary Vacuum Dryer**
**A.T.&M. 40"x30" Stainless Susp. Centrifuges, perf. & imperf. Baskets**
**Niagara #12 Stainless Steel jacketed Filter**
**Shriver Stainless 18" P&F closed 4 eye washing Filter Press**
**Buflovak 6' Dia. Crystallizers, atmospheric & Vacuum**
**Nash #9, #4, K5 and TS10 Hytor Vacuum Pumps**

**316 STAINLESS COLUMNS**

12"x20' Packed
36"x21' Packed
36"x17'—15 Bubble Cap Trays
48"x40'—36 Bubble Cap Trays
54"x30'—26 Bubble Cap Trays
72"x30'—21 Bubble Cap Trays
78"x18'—14 Bubble Cap Trays

**COPPER COLUMNS**

24"x 8'—15 Bubble Cap Trays
24"x17'—24 Bubble Cap Trays
30"x11'—12 Bubble Cap Trays
36"x12'—15 Bubble Cap Trays
48"x15'—26 Bubble Cap Trays
48"x31'—50 Bubble Cap Trays
72"x16'—16 Bubble Cap Trays

**TANKS**

**STAINLESS (dished heads)**
11000 gal. horiz. 8'x29'6"
6000 gal. Vert. 8' x 18'
5000 gal. Vert. w/coils
4500 gal. Vert. 8'x12'
3500 gal. Vert. w/coils
3500 gal. Horiz. 7'x12'
3500 gal. Vert. 8'x9'
1750 gal. Horiz. 6'x8'
1250 gal. Horiz. 5'x8'
1200 gal. 5'x8' agit.
1000 gal. 5'x7' agit.
950 gal. Vert. 5'x5'
750 gal. 5'x5' agit.
500 gal. 3'6"x8' agit.
500 gal. Vert. w/coils
400 gal. 4'x4' agit.
300 gal. 4'x3' cone bot.
150 gal. 3'x3' agit.
125 gal. Vert. 2'x5'
80 gal. Vert. 2'x3'6"

**GLASS LINED**
2000 gal. Vert. 6'6"x8'8"
2000 gal. Horiz. 6'x10'
750 gal. Horiz. 5'x5'
400 gal. Vert. 4'x4'

**ALUMINUM**
18000 gal. Horiz. 10'x30'
12000 gal. Horiz. 9'x26'
7000 gal. Vert. 10'x12'
6000 gal. Vert. 8'x16'
1500 gal. Vert. 5'x10'
750 gal. Vert. 4'6"x6'

**COPPER**
3500 gal. 8'x9' w/coils
3000 gal. 8'x8' w/coils
2000 gal. 7'x7' w/coils
500 gal. 4'x5' w/coils

**STEEL TANKS**
22000 gal. Vert. 12'x25'
11000 gal. Horiz. 8'x30'
8500 gal. Vert. 8'x22'
5000 gal. Horiz. 8'x12'
5000 to 250 gal. (50)

**HEAT EXCHANGERS**
2300 sq. ft. Stainless tubes
1000 sq. ft. All Stainless
600 sq.ft. Stainless tubes
600 sq. ft. Copper tubes
420 sq. ft. All Stainless
300 sq. ft. Stainless tubes
235 sq. ft. Stainless tubes
150 sq. ft. All Stainless
100 sq. ft. Stainless tubes
80 sq. ft. Stainless tubes
68 sq. ft. Stainless tubes
30 sq. ft. Stainless tubes
Glass Lined, jktd 30"x6'

**S.S. CENTRIF. PUMPS**
2x2" Model 15 DLP LaBour
2x2" Model H15-17 Durco
2x1½" 40-24MD Durco
1½x1" Model DHL LaBour

**STAINLESS**
**COPPER, STEEL, ALUM.**
**VALVES, PIPE & TUBING**

**MISCELLANEOUS**

Model "D" Fitzpatrick Comminuter
Squire 500 sq. ft. tray truck drier
Str. Wells Electric EH3 Dowtherm Heater
Anders Automatic Air Dehydrator
60 qt. Vertical Mixer & Bowls
Dorr Thickeners 20'x4'
Duriron Vessels 1000 to 100 gallon
Swenson 24"x20' Stainless 316 Crystallizer, Jktd.
Roots Connersville 8"x24" Blower 60000CFM
Norwalk Compressor Type SRSSR, 15000 PSI
Cleveland Size 400—VD gear reducers
Foote Bros. gear reducers Type 25W

*Your Inspection Invited—Representatives on Premises*
*Write—Wire—Phone for Complete Information*

## HEAT & POWER CO., Inc.

60 East 42 Street, New York 17, N. Y. Murray Hill 7-5280
Site Office—Pine Ave. & 47th St., Niagara Falls, N. Y. Butler 5-3644

CIRCLE R ON READER SERVICE CARD

---

New Stainless 4000 gal. vert. Tank.
Buffalo 32"x90" Double Drum Dryer.
Day Hy—R Speed Mill 20 HP Expl. Pr.
Centrifugals: 12", 30", 40" & 48".
Centrifuges: Sharples #5 & #6 Stainless.
Dryers: Hersey 5'x26' Rotary, 316 Stainless.
Buffalo Vac. Drum Dryer 24"x20".
Despatch Ovens Elec. Heated.
3—Devine & Stokes Vac. Shelf Dryers.
Filters: #2 Sweetland 12 Stainless Leaves.
Filter Presses: 6" to 36" Iron & Wood.
Kettles Tanks: S.S. Jack 20 to 4000 gal.
Dopp 350 gal. cast iron Jack. Vacuum.
Devine Impreg. Units 30" & 36" dia.
Mills: Raymond #00, 30 HP. & #0000.
Mikro Pulverizers #4, 2, 1, & Bantam.
Hammer Mills & Pulverizers 3 to 50 HP.
Taylor-Stiles 7½ HP. Cutter.
Rotary Cutters 1½ to 5 HP. & up.
Spr. Waldron Stainless spike crusher.
Pebble, Jar & Ball Mills, Lab. to 6' x 8'.
3 Roll, 9" x 32", 12" x 30", 16" x 40".
Lehman 4 Roll W.C. 12' x 36" Steel.
Colloid Mills 1½ H.P. & up.
Mixers: Baker Perkins jack. 100 gals.
Baker Perk. 15 HP. Masticator Mixer.
Day Imperial 75 & 150 gals.
Change Can Mixers 8, 15, 40, 150 gal.
Sprout-Wald. 10,000# horiz. Spiral Mixer.
Day Jumbo 700 gal. horiz. mixer.
Spiral Mixers, 3000, 1000# etc.
Lancaster 6' dia. 25 HP. & #1. 3 HP.
Pumps: Stokes etc. Vac. 10 to 500 CFM.
Gould 75 HP. Centrifugal 250 PSI.
Sifters: Day, Robinson, Rotex type.
Tablet Machines: Stokes R, Colton 4½ T, single punch. Stokes RD4 Rotary.
Hydr. Presses, Plastic & Rubber Machy.

*Partial Listings. Write For Bulletins*

**STEIN EQUIPT. CO.**

107-8th St., Brooklyn 15, N. Y. Sterling 8-1944

CIRCLE S ON READER SERVICE CARD

---

## PROFIT SAVERS

**54—VACUUM PUMPS**

**In Stock**

Stokes Model 212C each complete with 5 HP Motors. Capacity 115 CFM. Excellent condition. Special price on quantity purchases.

**MB MACHINERY AND EQUIPMENT CO.**
123 Townsend St. - San Francisco 7, Calif.

CIRCLE T ON READER SERVICE CARD

---

**SEARCHLIGHT Equipment Locating Service**

***No Charge or Obligation***

This service is aimed at helping you, the reader of "SEARCHLIGHT", to locate Surplus new and used equipment not currently advertised. (This service is for USER-BUYERS only.)

HOW TO USE: Check the dealer ads to see if what you want is not currently advertised. If not, send us the specifications of the equipment wanted on the coupon below, or on your own company letterhead to:

*Searchlight Section Locating Service*
*CHEMICAL ENGINEERING*
*P.O. Box 12, N.Y. 36, N.Y.*

Your requirements will be brought promptly to the attention of the equipment dealers advertising in this section. You will receive replies directly from them.

Searchlight Equipment Locating Service
CHEMICAL ENGINEERING
P. O. Box 12, N. Y. 36, N. Y.

Please help us locate the following equipment components.

.....
.....
NAME .....
TITLE .....
COMPANY .....
STREET .....
CITY .....1/23/61

# Why Jump around

# Select GELB

## CHEMICAL PROCESS EQUIPMENT

**1—Alloy Fabricators SS jacketed reactor 400 gal, complete with turbine agitator and Mixco drive**

**2—Pfaudler Series EM 300 gal. glass lined jacketed reactors, complete with anchor type agitators and drives**

**2—Alloy Fabricators type 316 SS pressure reactors, 4000 gal., complete with agitators and drives**

**1—American 42" x 120" double drum dryer, ASME, N.B. constructed, complete with drives and motors**

### AUTOCLAVES, KETTLES AND REACTORS

1—Oat Type 316 SS 10 gal. jacketed autoclave, 150 psi jacket and internal, complete with agitator and drive
2—Blaw Knox 600 gal. steel reactors, complete with double motion agitators and drives, 50# jacket, 50# internal
1—Steel 1200 gal. vertical pressure tank, 150 psi
3—Theo Walters 300 gal., Hastelloy B jacketed reactors
1—Van Alst 300 gal. stainless steel jacketed kettle
1—Blaw Knox 300 gal. stainless steel vacuum reactor
1—Alloy Fabricators Type 316 SS 2600 gal. vacuum receiver
1—Pfaudler Series EL 750 gal. glass lined jacketed reactor, 90# working pressure jacket, complete with impeller type agitator, baffle and drive
1—Pfaudler 30 gal. Series P. jacketed reactor, complete with impeller type agitator, baffle and drive
1—Struthers Wells Type 316 SS jacketed reactor 2000 gal. complete with agitator and drive

### DRYERS

2—Bonnet rotary kilns, 8' x 115', complete
1—Bonnet rotary cooler, 8' x 50', complete
1—Allis Chalmers stainless steel rotary dryer, complete, 6' x 50'
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
3—Link Belt steel roto louver dryers, Model 207-10, 310-16, 604-20
1—Hersey stainless steel rotary dryer, 3' x 20'
1—Buflovak stainless steel jacketed rotary rotary vacuum dryer, 3' x 15'
2—Stokes stainless steel jacketed rotary vacuum dryers, 3' x 15' and 2' x 6'
1—Proctor & Schwartz stainless steel apron dryer, 2' x 20'
3—Buflovak steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
1—Western Precipitation Corp. SS pilot plant spray dryer, Type N-2
1—Bowen Stainless steel pilot plant spray dryer
1—Stokes single door vacuum shelf dryer with 6 shelves, 24" x 36"

### FILTERS

12—Sweetland #12 filters with 72 stainless steel leaves
1—Niagara stainless steel filter, Model 510-28
1—Oliver horizontal filter, 3'
1—Oliver SS rotary vacuum pressure precoat filter, 5'3"
1—Oliver stainless steel rotary vacuum filter, 3' x 4'
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers
10—Shriver plate and frame filter presses, 12" to 42"

### CENTRIFUGES

1—AT&M 48" stainless steel, suspended type centrifuge, complete with plow, motor and imperforate basket
1—Fletcher 48" stainless steel, underdriven centrifuge, complete with perforate basket and motor

*THE GELB GIRL—JANUARY 1961*

7—Western States 40" type 316 SS, suspended type centrifuges, complete with perforate baskets, plows and 40 HP motors
1—AT&M 26" type 316 SS, suspended type centrifuge, complete with perforate basket, plow and motor
4—Tolhurst 40" center slung, rubber covered centrifuges, complete with perforate baskets and motors
1—Tolhurst 30" center slung, rubber covered centrifuge, with perforate basket and motor

### MIXERS

1—J. H. Day SS double arm sigma blade vacuum jacketed mixer, 5 gal.
2—Sturtevant #7 dustite rotary batch blenders, NEW
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Baker Perkins Size 16, TYPE UUEM, 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor
1—Stokes stainless steel granulating mixer, Model 21-J

### MISCELLANEOUS

1—Stewart Bolling 2 roll chrome plated plastic mill, 8" x 16"
1—Ross 6" x 14" 3 roll paint mill, complete
1—Vulcan stainless steel bubble cap column, 4' x 25 plates
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 and 600 sq. ft.
1—Downington type 316 SS heat exchanger, 750 sq. ft.
1—Griscom Russell stainless steel heat exchanger, 900 sq. ft.
4—Patterson type 316 SS condensers, 200 and 300 sq. ft.
4—Davis Engineering Carpenter 20 heat exchangers, 125 sq. ft. NEW
20—Davis Engineering stainless steel heat exchangers, 102, 119, 136, 166 sq. ft. NEW
2—Swenson type 316 SS vacuum crystallizers, 3'6" and 2' x 12'
1—Mikro #1SH pulverizer, complete
2—Mikro #3TH stainless steel pulverizers, complete with 40 HP motors

**2—Buflovak stainless steel rotary vacuum dryers, 5' x 30'**

**1—Baker Perkins SS double arm sigma blade mixer, 9 gal.**

**1—Robinson stainless steel 125 cu.ft. horizontal double ribbon blender**

**1—Raymond 2 roll high side roller mill**

## *Index of Advertisers*

## Advertising Sales Representatives


Atlanta 9 ..... R. K. Burnet
1375 Peachtree St. N.E., TRinity 5-0523
Boston 16 ..... A. S. Reed
McGraw-Hill Bldg., Copley Square, COngress 2-1160
Chicago 11 ..... Gene Davis, J. M. Rodger, Jr.
520 N. Michigan Ave. MOhawk 4-5800
Cleveland 13 ..... John G. Mitchell
55 Public Square SUperior 1-7000
Dallas 1 ..... Robert T. Wood
Vaughn Bldg., 1712 Commerce Riverside 7-9721
Denver 2 ..... John Patten
1700 Broadway ALpine 5-2981
Detroit 26 ..... Chas. M. Crowe, Jr.
856 Penobscot Bldg. WOodward 2-1793
Frankfurt/Main ..... Stan Kimes
85 Westendstrasse
Geneva ..... Michael R. Zeynel
2 Place du Port
Houston 25 ..... Gene Holland, John Grant
W-724 Prudential Bldg. JAckson 6-1281
London EC4 ..... E. E. Schirmer, Edwin E. Murphy
95 Farringdon St.
Los Angeles 17 ..... John B. Uphoff
1125 W. Sixth St. HUntley 2-5450
New York 36—R. G. Frederick, A. L. Gregory
John R. Emery
500 Fifth Ave. OXford 5-5959
Philadelphia 3 ..... E. M. Schellenger
6 Penn Center Plaza LOcust 8-4330
Pittsburgh 22 ..... G. S. Ryan
4 Gateway Center EXpress 1-1314
Portland 4 ..... Scott B. Hubbard
Room 445, Pacific Bldg. CApitol 3-5118
St. Louis 8 ..... J. M. Rodger, Jr.
3617 Olive Street JEfferson 5-4867
San Francisco 4 ..... R. T. Koch
68 Post St. DOuglas 2-4600

ADVERTISERS . . .



CLASSIFIED ADVERTISING

F. J. Eberle, Business Mgr.



ADVERTISERS INDEX

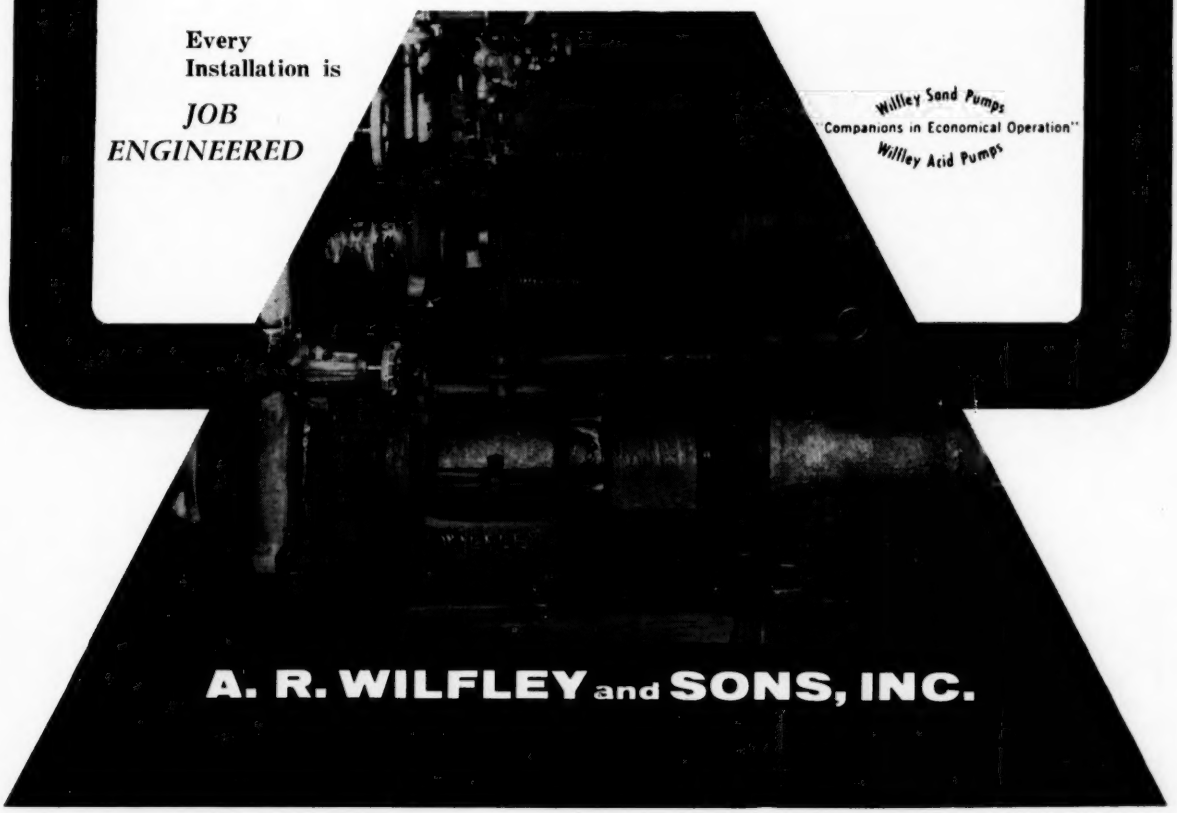
# WILFLEY
## ACID PUMPS

# Continuous, Low Cost Service

Twenty-four hour, maintenance-free operation is one big reason why Wilfley Acid Pumps consistently give you lower pumping costs. Add to this Wilfley's low installation cost, packingless design, longer pump life, plus higher output, and you have maximum pumping economy.

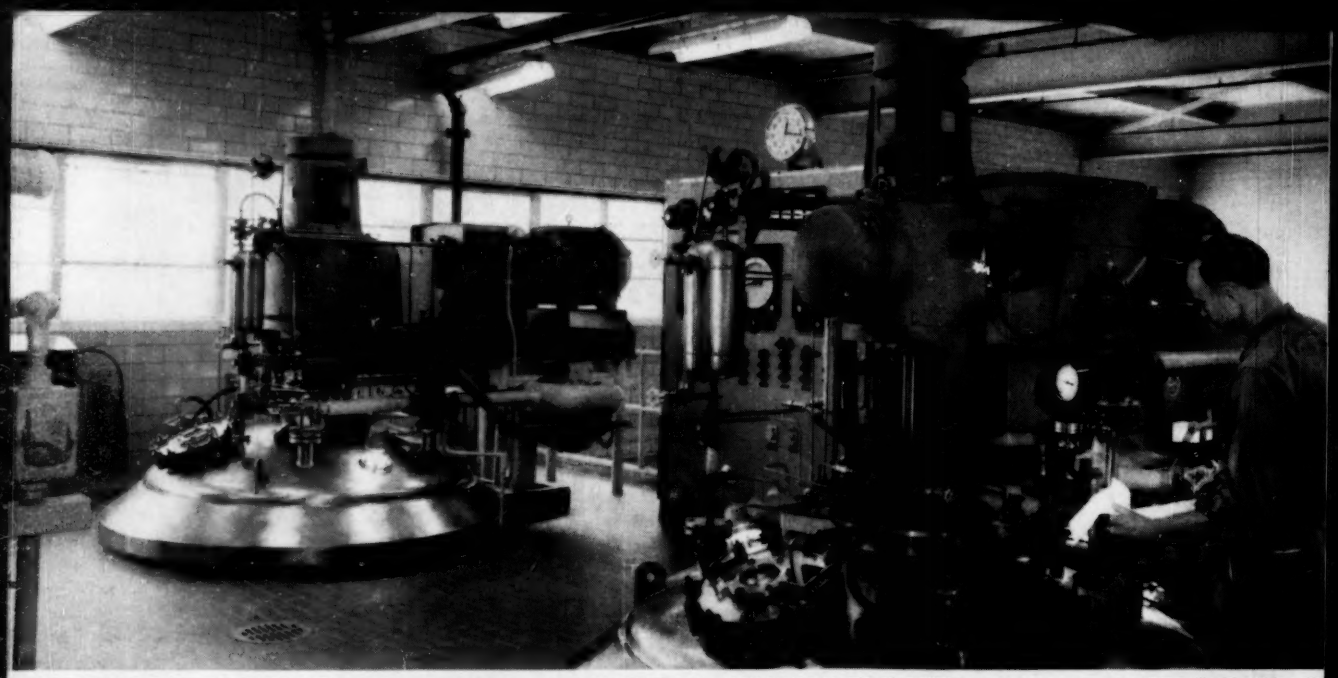
A wide range of corrosive applications can be covered with a variety of metal alloys as well as plastic. 1″ to 8″ discharge sizes are available with 10 to 3000 GPM capacities and heads up to 200′ and higher. Write, wire or phone for complete information.

**Every Installation is** *JOB ENGINEERED*



Wilfley Sand Pumps
"Companions in Economical Operation"
Wilfley Acid Pumps

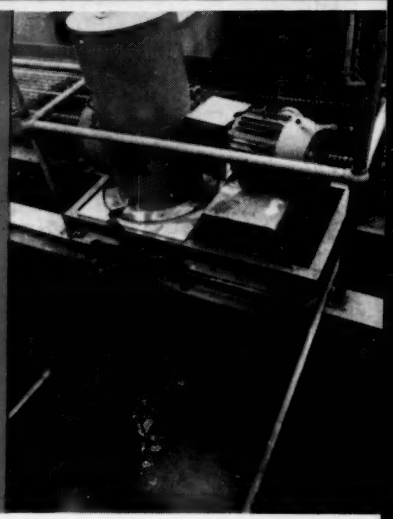
**A. R. WILFLEY and SONS, INC.**



**1. REACTION.** In 3000-gal. fermenter kettles (above), turbine-type LIGHTNIN Mixers with variable-speed drives insure precise process control. Installed over a year ago, both mixers have operated without trouble from startup.

**2. HOLDING.** Fermented broths (left) are kept in uniform suspension in 5000-gal. hold tanks. Each LIGHTNIN Side Entering Mixer is equipped with rotary mechanical seal that makes repacking unnecessary and eliminates stuffing-box adjustment.

**3. WASTE NEUTRALIZATION.** Here (at right) is one of three LIGHTNIN Mixers neutralizing acid waste in concrete basins. In five years of continuous service, there has been no serious downtime.



# How to cut downtime in 3 places at once

*Photos courtesy of Schering Corporation, Union, N. J.*

"About all we need to do is change the oil once in a while," says Arnold R. Jackson, project engineer.

He's talking about the LIGHTNIN Mixers used on an important fermentation process by his company, Schering Corporation, Union, N. J.

"We've been using LIGHTNIN Mixers for ten years," declares Jackson. We specify them because they do the job. We'll keep on using them as long as we get the performance we've been getting."

### The "why" of low-cost mixing

There are many reasons why you minimize costly downtime when you mix with LIGHTNIN Mixers.

Mechanical reasons, such as exclusive LIGHTNIN hollow-quill design that protects mixer gears in case of sudden shock load on the mixer shaft.

Shaft seal assemblies that make it unnecessary ever to repack a mixer stuffing box—and that a man can replace, if need be, *in minutes.*

Mixers that come all assembled in one package, aligned and ready to install and run.

To get an idea of how many dollars your company can save with fluid-mixing advantages like these, call in your LIGHTNIN Mixer representative. You'll find his name in Chemical Engineering Catalog and in the yellow pages of your telephone book. Or write us direct.

**Lightnin® Mixers**

MIXCO fluid mixing specialists

**MIXING EQUIPMENT Co., Inc., 128-a Mt. Read Blvd., Rochester 3, N.Y.**

*In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.*

*In Europe: Lightnin Mixers, Ltd., Poynton, Cheshire, England*